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OMB No 0704-0188

Public reporting ... per response, including the time for reviewing instructions, searching existing data sources, gathering and m... of information. Send comments regarding this burden estimate or any other aspect of this collection of inf... Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, ... and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	22 Dec 89	Aug 88 - Dec 89

4. TITLE AND SUBTITLE	5. FUNDING NUMBERS
Technology Insertion (TI)/Industrial Process Improvement (IP) Task Order No. 1 Contract Summary Report/Quick Fix Plan for SA-ALC, 7 RCC's	Contract
6. AUTHOR(S)	
McDonnell Douglas Missile Systems Company	

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)	8. PERFORMING ORGANIZATION REPORT NUMBER
McDonnell Douglas Missile Systems Company St. Louis, Missouri 63166	F33600-88-D-0567

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSORING/MONITORING AGENCY REPORT NUMBER
HQ AFLC/LGME WPAFB OH 45433	F33600-88-D-0567

11. SUPPLEMENTARY NOTES

Prepared in cooperation with SA-ALC & HQ AFLC.

12a. DISTRIBUTION / AVAILABILITY STATEMENT	12b. DISTRIBUTION CODE
Distribution Statement A	

13. ABSTRACT (Maximum 200 words)

Technology Insertion (TI)/Industrial Process Improvement (IPI) Summary Report for SA-ALC. This document contains Focus Study and Quick Fix Recommendations for 7 Resource Control Centers (RCC's). These RCC's are: MABPSA, MABPSB, MABPSC, MABPSP, MATPGB, MATPSI & MATPSS

14. SUBJECT TERMS	15. NUMBER OF PAGES
MAINTENANCE, QUICK FIX, TECHNOLOGY INSERTION, RESOURCE, AFLC, SA-ALC, INDUSTRIAL PROCESS	229
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	Unclassified

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102

TECHNOLOGY INSERTION-ENGINEERING SERVICES
PROCESS CHARACTERIZATION
TASK ORDER NO. 1

VOLUME V
SA-ALC

CONTRACT SUMMARY REPORT AND QUICK FIX PLAN
25 SEPTEMBER 1989
REVISION A - 22 DECEMBER 1989

CONTRACT NO. F33600-88-D-0567
CDRL SEQUENCE NO. B008 AND B007

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS AND ABBREVIATIONS

ADG	ACCESSORY DRIVE GEARBOX
AFLC	AIR FORCE LOGISTICS COMMAND
AFR	AIR FORCE REGULATION
ALC	AIR LOGISTICS CENTER
AMAD	AIRFRAME MOUNTED AUXILIARY DRIVE
APIS	AUTOMATED PROMPTING INSPECTION STATION
APU	AUXILIARY POWER UNIT
A/R	AS REQUIRED
ATP	ACCEPTANCE TEST PLAN
CBA	COST BENEFIT ANALYSIS
CGB	CENTRAL GEAR BOX
CMM	COORDINATE MEASURING MACHINE
CNC	COMPUTER NUMERICAL CONTROL
CSR	CONTRACT SUMMARY REPORT
CUM	CUMULATIVE
DDB	DATABASE DOCUMENTATION BOOK
DMM	DIMENSIONAL MEASUREMENT MACHINE
DMMS	DIRECT MATERIAL MANAGEMENT SYSTEM
E&I	EVALUATION AND INSPECTION
FPI	FLUORESCENT PENETRANT INSPECTION
FY	FISCAL YEAR
GFI	GOVERNMENT FURNISHED INFORMATION
GPU	GROUND POWER UNIT
GTE	GAS TURBINE ENGINE
HQ	HEADQUARTERS
ID	IDENTIFICATION DATA
IE	INDUSTRIAL ENGINEER(ING)
IRR	INTERNAL RATE OF RETURN
JFS	JET FUEL STARTER
JIT	JUST IN TIME
LIFT	LOGISTICS IMPROVEMENT OF FACILITIES AND TECHNOLOGY

MA	DIRECTORATE OF MAINTENANCE
MAB	AIRCRAFT DIVISION
MAT	TECHNOLOGY REPAIR DIVISION
MDMSC	MCDONNELL DOUGLAS MISSILE SYSTEMS COMPANY
MISTR	MANAGEMENT OF ITEMS SUBJECT TO REPAIR
MPI	MAGNETIC PARTICLE INSPECTION
NPV	NET PRESENT VALUE
OC-ALC	OKLAHOMA CITY AIR LOGISTICS CENTER
OJT	ON THE JOB TRAINING
PAC	PRODUCTION ACCEPTANCE CERTIFICATION
PCN	PART CONTROL NUMBER
PDM	PROGRAMMED DEPOT MAINTENANCE
PM	PREVENTATIVE MAINTENANCE
PO	PURCHASE ORDER
PVC	POLY VINYL CHLORIDE
QDR	QUALITY DISCREPANCY REPORT
QFP	QUICK FIX PLAN
RCC	RESOURCE CONTROL CENTER
ROI	RETURN ON INVESTMENT
ROM	ROUGH ORDER OF MAGNITUDE
SA-ALC	SAN ANTONIO AIR LOGISTICS CENTER
SMDD	SIMULATION MODEL DEFINITION DOCUMENT
TI-ES	TECHNOLOGY INSERTION-ENGINEERING SERVICES
T&M	TEMPORARY AND MANUFACTURING
TO	TASK ORDER
UDOS	UNIVERSAL DEPOT OVERHAUL SIMULATOR
WCD	WORK CONTROL DOCUMENT
WG	WAGE GRADE
WIP	WORK IN PROCESS
WP	WORK PROCEDURE

INDEX OF PAGE CHANGES
SA-ALC CSR

REVISION DATE AND LETTER	PAGES AFFECTED			REMARKS
	REVISED	ADDED	REMOVED	
12-22-89-A	Title ii iii iv v vi vii 8.0-1 thru 8.0-15 8.1-1 thru 8.1-16 8.2-1 thru 8.2-13 8.3-1 thru 8.3-55 8.4-1 thru 8.4-17 8.5-1 thru 8.5-22 8.6-1 thru 8.6-19 8.7-1 8.7-9 8.7-11 8.7-14	ix 8.1-17 8.1-18 8.1-19 8.1-20 8.2-14 8.2-15 8.2-16 8.2-17 8.3-56 8.4-18 8.5-23 8.5-24 8.5-25 8.5-26 8.5-27 8.5-28 8.6-20 8.6-21 8.6-22	8.0-16	INCORPORATE CUSTOMER COMMENTS

LSC-20694A

SA-ALC CONTRACT SUMMARY REPORT

8.0 SAN ANTONIO AIR LOGISTICS CENTER (SA-ALC)

During the fourth quarter of FY 89 McDonnell Douglas Missile Systems Company (MDMSC) completed process characterization of seven Resource Control Centers (RCCs). The purpose of this process characterization was to accomplish an engineering assessment and determine an As-Is baseline description of RCC operations, from which improvements could be measured. The data gathered during the process was used to drive a stochastic simulation model of the RCC, using the UDOS 2.0 model developed for this contract. The development and structure of the UDOS 2.0 model is described in detail in the Simulation Model Definition Document (SMDD) previously delivered by MDMSC.

Three of the RCCs characterized are in the Technology Repair Division (MAT) and four are in the Aircraft Division (MAB). The process characterization was performed as a part of the Technology Insertion-Engineering Services (TI-ES) Program and was completed in three separate activity blocks as part of Task Order No. 1:

Block I: MATPGB, MATPSI, MATPSS
Block II: MABPSA, MABPSB, MABPSP
Block III: MABPSC

Initially, MABPSA, MABPSB and MABPSP were scheduled for characterization in Block I, and MATPGB, MATPSI and MATPSS were to be done in Block II. However, the order was reversed due to the delay in obtaining contractor security clearance for entry into the Building 375 restricted area.

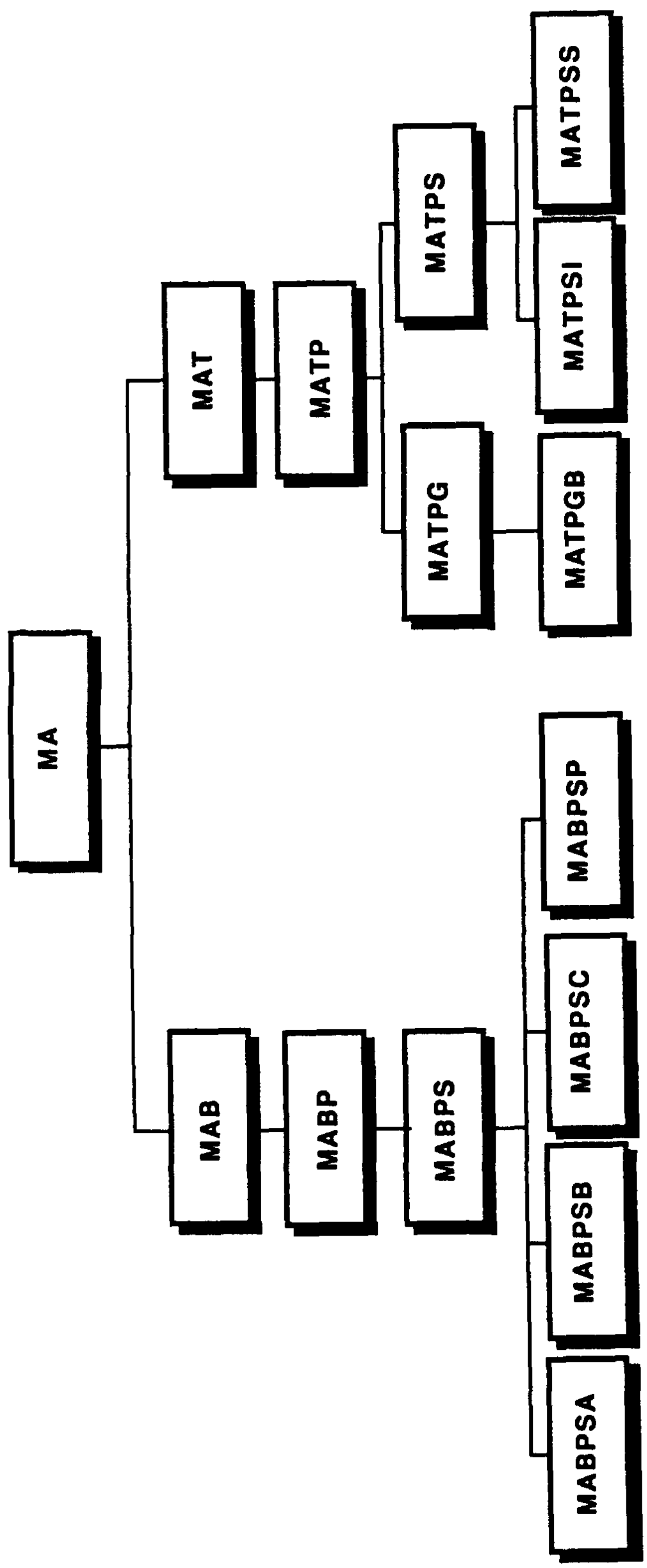
This Contract Summary Report (CSR) addresses the seven RCCs characterized in Task Order No. 1 of the TI-ES contract, describes processes observed during data collection, and discusses results of experimentation with the UDOS 2.0 simulation model. It provides an overview of MDMSC effort and details recommendations for improvement of SA-ALC production operations.

During the process of I.E. assessment and data collection in the RCC, opportunities for improvement were identified by MDMSC engineers. Simple, low cost opportunities with well-defined payoffs were categorized as quick fixes, opportunities with unquantifiable payoffs were categorized as observations, and those recommendations requiring further study were addressed as focus study recommendations. The details of these opportunities are described in the Quick Fix Plan (QFP) and individual RCC sections of this report. Experimentation with the validated model and on site observation resulted in recommendations for four focus studies, six quick fixes, and numerous other observations. The focus studies and quick fixes were selected by the SA-ALC/MDMSC team as targets for further investigation.

The findings and assessments for each RCC are summarized in the individual RCC sections of this report. The bulk of the supporting data and details of the analysis performed are included in the Database Documentation Book for each RCC, delivered in conjunction with this report, under separate cover.

Experimentation results indicate that of the seven RCCs analyzed, three (MATPGB, MATPSI, and MABPSB) are unable to meet wartime surge workloads at current manpower and equipment levels. Details are discussed in each RCC's respective Statistical System Performance Measure paragraph.

The Air Force selected the seven SA-ALC RCCs to be characterized. (See Figure 8.0-1 for the organization chart of the maintenance directorate hierarchy for the selected RCCs.) MDMSC identified the assemblies and repair processes to be characterized and modeled based on an 80/20 workload concept utilizing the G019C report of Management of Items Subject to Repair (MISTR) furnished by SA-ALC. The significant PCNs were identified using an 80/20 Pareto analysis, based on FY 88 cumulative earned hours per PCN. Those PCNs which accounted for 80% of the G019C MISTR workload in FY 88 were selected for process characterization. Where MISTR items did not constitute 100% of an RCC's workload, adjustments were made in model resource availability to compensate. SA-ALC program management was



LEGEND:
MA — DIRECTOR OF MAINTENANCE
MAB — AIRCRAFT DIVISION
MABP — PRODUCTION BRANCH
MABPS — COMPONENT REPAIR SECTION
MABPSA — WING & SURFACE UNIT
MABPSB — SHEET METAL REPAIR UNIT
MABPSC — SHEET METAL MANUFACTURING UNIT
— WELDING & HEAT TREAT UNIT
MABPSP — BONDING & PLASTIC UNIT
MAT — TECHNOLOGY REPAIR DIVISION
MATP — PRODUCTION BRANCH
MATPG — GTE REPAIR SECTION
MATPGB — GTE DISASSEMBLY, ASSEMBLY & TEST UNIT
MATPS — AUXILLARY POWER SECTION
MATPSI — STARTER DISASSEMBLY, CLEANING & INSPECTION UNIT
MATPSS — STARTER ASSEMBLY & TEST UNIT

LSC-20302

SA-ALC RCC PROCESS CHARACTERIZATION — TASK ORDER NO. 1
FIGURE 8.0-1

involved in the 80/20 development throughout the process. Details are available in the appropriate paragraph for each RCC.

Discussions with both RCC supervision and SA-ALC program management resulted in agreement to use the G019C MISTR report for 80/20 characterization on the grounds that MISTR adequately represented the majority of the workload in all RCCs except MABPSC.

To accomplish process characterization, process and flow time data were collected for each modeled PCN from the applicable WCD and interviews with operators and supervisors within the RCC. The WCD was examined for currency and accuracy. Where the WCD was found to be inaccurate, it was marked up to reflect the As-Is process, as described by the operator. Interviews were conducted with operators (selected by RCC management) to learn the details of each operation. The data collected included: the time required to perform the operation (including part handling and setup), the tools and equipment needed to perform the operation, the average number of times the operation is performed for each PCN, and the numbers and skill levels of the operators required to perform the operation. Where the PCN left the RCC for processing in a back shop, the time required was captured, but no details of the back shop processes were included in the model database. This interview methodology was used under the assumption that the ALC worker who performs a task is the best source of information on this task. While historical data on actual operation times would have been preferable, this data is not currently captured at SA-ALC. All data collected was made available to RCC supervisors for review. Where errors in model output were traced to erroneous interview data, the data was revised during the model validation process.

The UDOS models for each RCC identified the existence of delays after induction, when parts were waiting to begin their first operation. These delays were examined during validation and modified as required, to reflect the actual situation in the RCC.

Resource data was collected from RCC management. Each supervisor was asked to identify, by quantity and skill level, the work force in his/her area in FY 88. Where workers were interchangeable across area lines, the appropriate relationships were identified. These supervisors also provided data on the shift scheduling and overtime occurrences they experienced in FY 88. Data on equipment, including maintenance and failure downtimes, was provided by RCC supervisors using the equipment logs. Where log data was not available or inadequate, supervisory estimates were used. The use of supervisory estimates as a source for resource data carries the same assumptions and risks as those identified in the interview process description. There is always a risk of inaccuracy/misinterpretation when subjective data is used, however, there was no better data available at SA-ALC. Given the performance of supervisory reviews and model verification/validation, MDMSC considers the risk of critical error to be extremely small.

The induction rates for each PCN were based on actual FY 88 inductions. FY 88 was chosen as the baseline for the model because it was the last complete fiscal year for which actual data was available.

Historical data on PCN flow times was collected by keypunching the PAC stamp dates on completed WCDs into a statistical database. In many cases this data was either completely unavailable, or of such poor quality that it could not be used. The most common problems appeared to be the operator's failure to stamp an operation on the WCD, or his stamping off all operations at once, before the PCN leaves the RCC. This lack of meaningful history made it very difficult to track the effects of process changes or to perform good industrial engineering within the RCCs. Further coverage of this situation is provided in paragraph 3.0 of this report.

A joint MDMSC/SA-ALC team was formed to validate the model as reflecting a true baseline condition. The process used for this effort is described in detail in the Acceptance Test Plan (ATP) previously delivered by MDMSC. Details of the results for each RCC are available in the minutes of each validation meeting and in that RCC's individual section of this report.

Three RCCs (MATPGB, MATPSS, and MATPSI) are responsible for the remanufacturing of Gas Turbine Engines (GTEs), Jet Engine Starters and Gear Boxes. The three RCCs underwent reorganization in 1988 to separate disassembly, and assembly operations. MATPGB performs both disassembly and assembly but at opposite ends of Building 329. See Figure 8.0-2.

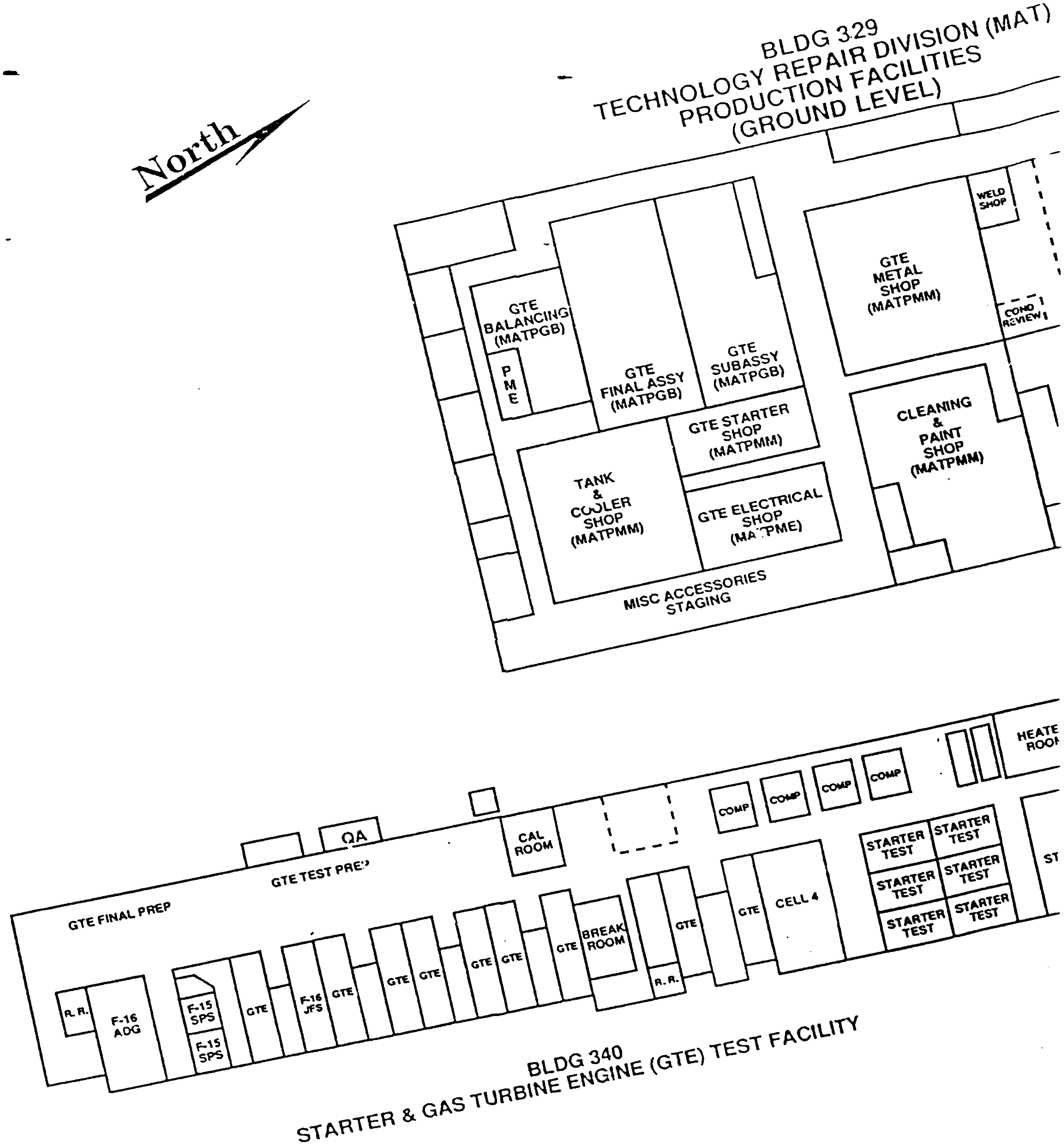
MATPSI and MATPSS both handle the same auxiliary power end items, but are functionally distinct. Disassembly, cleaning and inspection are performed by MATPSI, and assembly and test are performed by MATPSS. As a result there is no possibility that disassembled parts and subassemblies could be reassembled on end items without going through necessary cleaning and inspection.

The three Block II RCCs characterized were the Aircraft Division's MABPSA, MABPSB, and MABPSP. These shops repair B-52 and C-5 engine cowls, pylons, flaps, spoilers, and flight controls.

MABPSA is well-organized with its cellular concept of shop layout. The co-location of processes pertaining to particular products economizes on space and movement of both personnel and material. Tooling is basic, as are the stands and fixtures used for holding end items during disassembly, inspection, repair, and reassembly. This RCC depends on MABPAR (paint shop) for stripping, cleaning, corrosion treatment, and painting. Supervisors report that this dependency causes problems due to long back shop turnaround time. MDMSC recommends an analysis of MABPAR workload scheduling to reduce flow time and improve throughput.

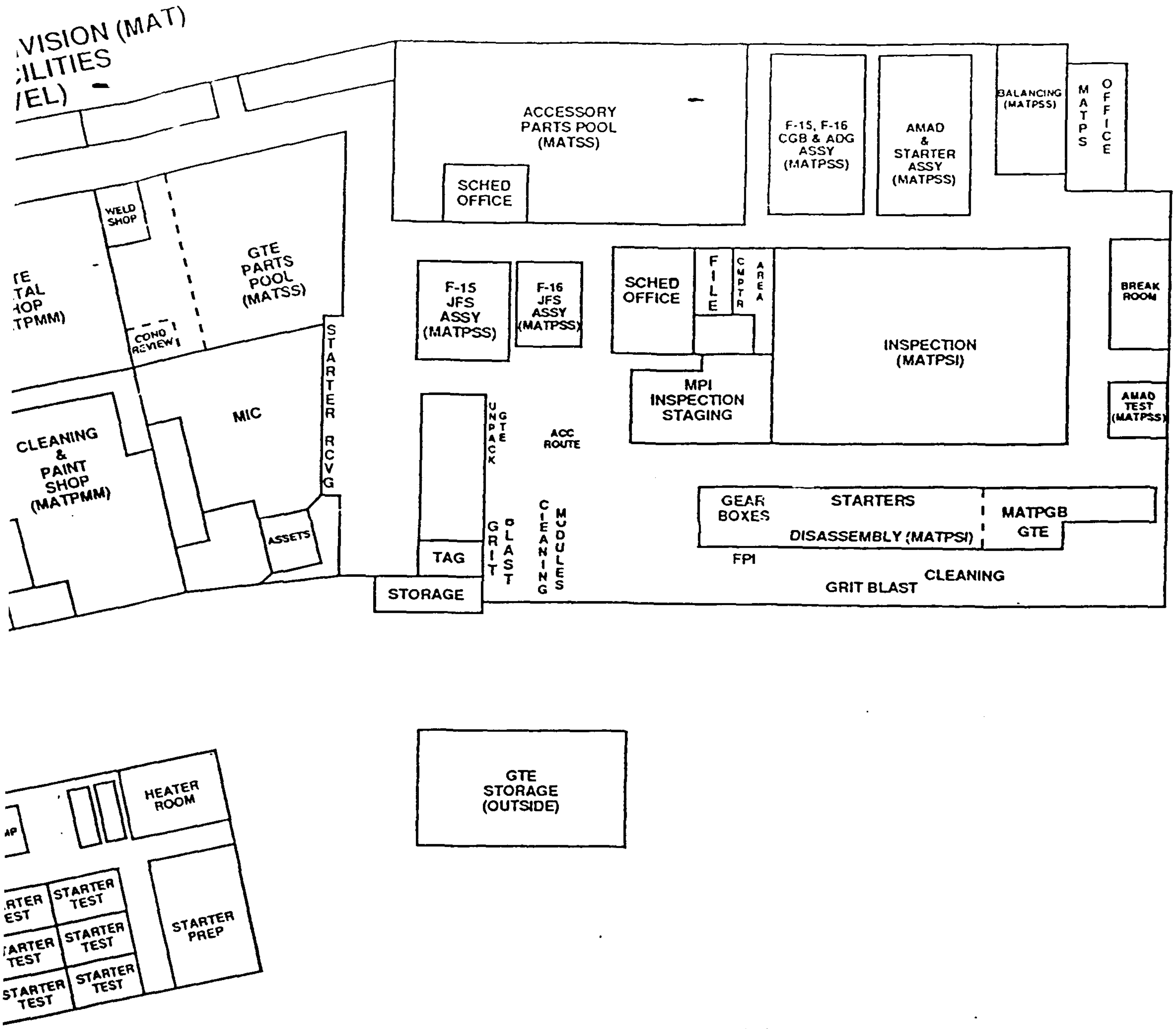
During process characterization, no unusual amount of work in process was noticed inside the shop. The work areas were kept very neat and clean, and no health or safety problems were observed (aside from MABPSP sanding discussed later in this section).

MABPSB is well-organized and laid out to facilitate access for personnel and material movement to and from the supporting back shops within the building.



BUILDINGS 329 AND 340 SIMPLIF

FIGURE 8.0-2



NOT TO SCALE

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) 340 SIMPLIFIED LAYOUT (SA-ALC)
FIGURE 8.0-2

The work area is suitably equipped with the sheet metal tools needed to produce quality repairs. This RCC interfaces with several other RCCs for support in cleaning, paint stripping, corrosion treatment, dye penetrant inspection, and painting. One of the supporting RCCs, MABPAN (Non-destructive Inspection and Testing Unit), creates a flow time problem for MABPSB by taking longer than desirable time to process the C-5A engine inlet cowl. This back shop delay appears to be caused by MABPAN's prioritizing procedures. This issue is discussed further in the Quick Fix Plan.

During validation, the RCC supervisor commented strongly on the inaccuracy of standard labor hours for his shop's tasks, stating that he worked longer than the hours he was paid for. This suggests that a review of both planning and the establishment of work standards has not been done regularly. The interview data obtained by MDMSC varied widely from published standards.

MABPSP specializes in the repair of bonded honeycomb structures, as well as, performing standard repairs of drilling, rivetting, etc. The RCC is organized into four major areas by processes required. The repair area is crowded, while the anodize, layup, and autoclave areas have adequate floor space.

The RCC personnel seem well-trained in the specialized repair processes required to repair honeycomb structures, as well as the standard repair procedures.

Much of the disassembly and assembly processes are accomplished by hand using standard tools, both manual and motor-driven. In addition, many special hand tools have been developed by the RCC to aid the mechanic in repairing these honeycomb assemblies. Holding fixtures, for the most part, are benches and stands. There are also special holding fixtures and special bonding fixtures required by the configurations of some assemblies. The tools and fixtures are adequate for the function of this RCC. Even though the repair area is crowded, the work is well-organized and the area is relatively clean, considering the type of processes performed.

Most of the repair work is accomplished in MABPSP. Substantial support is required from MABPAR to clean, strip paint, corrosion treat, and paint the assemblies.

The only Block III RCC characterized is MABPSC. It, too, is part of the Aircraft Division. This RCC has two major functions: fabricate sheet metal parts, and welding and heat treating.

MABPSC is organized into five major sub-units as follows:

- Layout
- Power Equipment
- Sheet Metal Fabrication
- Welding and Heat Treating
- Alodine Processing

The present layout is a culmination of many changes over a period of years. As a result, most of the RCC is crowded and congested, with poor material flow, and equipment placement. Equipment and special tools are excellent in some areas and very poor in others. A detailed analysis of equipment and tools is provided in paragraph 8.3.1 of this CSR.

The RCC personnel appear to have a good attitude, but are frustrated by the lack of proper/adequate tooling and poor and broken equipment. The workload in MABPSC is consistently backlogged, as they must continually respond to critical parts shortages for PDM and MISTR requirements ahead of their other workload. The planning is issued by the RCC Layout mechanics, rather than trained planners, and consists of one generic WCD.

In MABPSC a dependency on MAT for tool fabrication and/or repair causes problems as MAT services its own priorities first. A similar problem exists between MAT and MAE where parts are sent to the back shop for chemical cleaning. MAE's engines take precedence, and MAT suffers flow time delays.

The ALC has implemented many improvements, such as improved engine and jet fuel starter test cells in MAT, and new numerically-controlled equipment in MABPSC (Sheet Metal Manufacturing). Some of these changes have resulted from detailed Air Force analysis as discussed in the SA-ALC LIFT Plan. Funding limitations, however, have precluded accomplishing all, or even a significant portion, of needed changes. A new replacement test facility (Building 331) for MAT's engines and starters has been in abeyance for years. A new cleaning area scheduled for development in fourth quarter FY 89 has been "in work" since at least 1985. When funds become available, projects are implemented piecemeal. Floor layouts then evolve in what appears to be a random, inadequately-planned arrangement.

During process characterization and model experimentation, four focus studies and ten quick fixes were selected for further investigation. Following the August 1989 Program Management Review, an SA-ALC/MDMSC meeting was held during which four of the MAT quick fixes were dismissed or changed to observations. A summary of the focus studies and the remaining six quick fixes discussed in the following sections of this report is presented in Tables 8.0-1 and 8.0-2. The estimated savings are shown for each item.

The first focus study titled, "Improve Product Quality and Cost by Machine Forming of Parts," detailed in paragraph 8.3.4 proposes that a large percentage of parts presently fabricated manually could be machine-formed, resulting in a significant improvement in productivity. This focus study will address current and projected workload, evaluate existing equipment and tooling, determine tools and equipment required, skill level of employees, and training requirements. MDMSC estimates labor cost savings of over $1.2M NPV over five years if the recommendations of this focus study are implemented.

The second focus study titled, "Provide an Efficient Process for Cutting Parts to Outline," detailed in paragraph 8.3.5, proposes another method of fabricating parts faster and more efficiently. The present method is accomplished primarily by hand (shear, saw and file or sand to outline). The proposed method would be accomplished using steel-rule dies to blank out a part to outline with one

SA-ALC FOCUS STUDY RECOMMENDATION SUMMARY

TABLE 8.0-1

	MDMSC RECOMMENDATION	IMPACT	ANNUAL BUDGET SAVINGS	COST AVOIDANCE			INVESTMENT COST
				FLOW TIME REDUCTION	WIP INVENTORY REDUCTION*	FLOOR SPACE REDUCTION	
8.3.4	MACHINE FORM PARTS (MABPSC)	DIRECT LABOR SAVINGS	$ 428,197	0 DAYS	$ 0	0 SQ. FT.	$ 375,000
8.3.5	MACHINE CUTTING PARTS (MABPSC)	DIRECT LABOR SAVINGS	$ 97,310	0 DAYS	$ 0	0 SQ. FT.	$ 225,000
8.5.4	BALANCE PROCESS FLOW (MATPGB, MATPSI, MATPSS)	INVENTORY REDUCTION	$ 0	23 DAYS	$ 3,670,000	0 SQ. FT.	$ 380,000
8.6.4	IMPROVE PARTS CLEANING - BLDG. 329 (MATPSI)	INVENTORY REDUCTION	$ 0	23 DAYS	$ 367,000	0 SQ. FT.	$ 250,000
	TOTALS		$ 525,507	23 DAYS	$ 4,037,000	0 SQ. FT.	$ 1,230,000

NOTES: * WIP INVENTORY REDUCTION = $\frac{\text{\# OF FLOW DAYS REDUCED}}{\text{365DAYS}}$ X (ASSET $ VALUE) X (YEARLY PRODUCTION RATE)

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SA-ALC QUICK FIX RECOMMENDATION SUMMARY
TABLE 8.0-2

	MDMSC RECOMMENDATION	IMPACT	BUDGET SAVINGS	COST AVOIDANCE			INVESTMENT COST
				FLOW TIME REDUCTION	WIP INVENTORY REDUCTION*	FLOOR SPACE REDUCTION	
8.3.1	CUT STOCK TO SIZE (MABPSC)	DIRECT LABOR SAVINGS	$ 31,150	0 DAYS	$ 0	0 SQ. FT.	$ 13,240
8.3.4	BRIDGE CRANE (MABPSC)	DIRECT LABOR SAVINGS	$ 24,100	0 DAYS	$ 0	0 SQ. FT.	$ 22,000
8.7.3	TRANSFER INSPECTION WCDs (MATPSI, MATPSS)	DIRECT LABOR SAVINGS	$ 11,200	0 DAYS	$ 0	0 SQ. FT.	$ 500
8.3.3	ID TAGS (MABPSC)	DIRECT LABOR SAVINGS	$ 10,190	0 DAYS	$ 0	0 SQ. FT.	$ 0
8.3.2	FREEZER CHESTS (MABPSC)	DIRECT LABOR SAVINGS	$ 4,700	0 DAYS	$ 0	0 SQ. FT.	$ 1,500
8.2.1	DYE PENETRANT INSPECTION (MABPSB)	DIRECT LABOR SAVINGS	$ 2,700	0 DAYS	$ 0	0 SQ. FT.	$ 690
	TOTALS		$ 84,040	0 DAYS	$ 0	0 SQ. FT.	$ 37,930

NOTES: * WIP INVENTORY REDUCTION = $\frac{\text{\# OF FLOW DAYS REDUCED}}{\text{365DAYS}}$ X (ASSET $ VALUE) X (YEARLY PRODUCTION RATE)

QUICK FIXES ARE LISTED HERE IN DESCENDING ORDER OF BUDGET ORDER OF BUDGET SAVINGS, NOT THE SEQUENCE OF PARAGRAPH 8.0 TEXT.

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stroke of a press. MDMSC estimates labor cost savings of over $143,000 NPV if the recommendations of this focus study are implemented.

The third focus study titled, "Reduction of Parts Inventory and Improvement in Flow Time/Throughput," detailed in paragraph 8.5.4, proposes a multi-faceted approach to reducing the high cost of Work In Process (WIP) and inventory for all RCCs in MAT. The concept is based on balancing production operations, adjusting induction methods, and reducing material handling and storage systems. The focus study will address both normal and surge conditions. Lengthy turnaround of repairable items means that more items must exist in USAF inventory to provide a buffer, and buffer stocks are expensive. Substantial savings can be obtained by reducing the amount of material in the overhaul pipeline, making more assets available in the field. MDMSC estimates inventory reductions worth over $24 million NPV, and a floorspace savings of 16,000 square feet, in the recommendations of the focus study are implemented.

A fourth focus study titled, "Improvements in Parts Cleaning in Building 329," discussed in paragraph 8.6.4, proposes a redesign of the MATPSI cleaning processes. The thrust of the study is to reduce process delays and increase cleaning capability. A major benefit of redesigning the cleaning processes will be the reduction of processing time with an estimated reduction of work-in-process inventory of $367,000. This focus study applies to MATPSI, but directly affects MATPGB and MATPSS assembly as well.

The first quick fix titled, "Reduce the C-5A Engine Inlet Cowl Panel Dye Penetrant Inspection Time," proposes an annual savings of over $2,700 by performing this inspection in a portable booth within the MABPSB shop. Flow time would improve and personnel would be used more effectively.

The second quick fix titled, "Provide Raw Stock Cut to Rough Size to Mechanics," proposes that all raw material be cut to rough size in the storage area and provided to the mechanics. The current method requires all the mechanics to go to the raw stock area, get the material they need, return to the

fabrication area, and cut the stock to size. An estimated annual savings of $31,150 is expected. See paragraph 8.3.1 in the QFP for details. See paragraph 8.2.1 in the QFP.

The third quick fix titled, "Provide Freezer Chests Near Work Benches," proposes additional freezers be provided closer to the mechanics' work benches to eliminate the longer walking distances and numerous trips they are now making to retrieve material from the big freezer. An estimated annual savings of $4701 is expected. See paragraph 8.3.2 in the QFP for details.

The fourth quick fix titled, "Improve Process for Making ID Tags," proposes that ID tags for part identification be made by one individual (on light duty or handicapped) and provided to the fabrication mechanics along with the work order as opposed to the present method of all the fabrication mechanics making the ID tags. An estimated annual savings of $10,190 is expected. See paragraph 8.3.3 in the QFP for details.

The fifth quick fix titled, "Improve Material Handling and Floor Space Utilization for the Arc Weld and Heat Treat Shop," proposes that a bridge crane be installed in this area to move large heavy parts efficiently as opposed to the movement of parts by the current monorail system, with its limited capability. It is estimated that this improvement will pay for itself in the first year. An estimated annual savings of $24,100 is expected. See paragraph 8.3.4 in the QFP for details.

The sixth quick fix titled, "To Reduce End Item Assembly Time," recommends that visual inspection, nick, and deburring of hardware items which are presently done in MATPSS assembly be done in MATPSI (inspection). The current practice consumes the time of an assembly mechanic for work which could be done by a lower labor grade in a unit whose function is inspection. Primary cost savings ($11,200) result from more effective use of skilled labor and reducing delays in the assembly process. See paragraph 8.7.1 in the QFP for more information.

Throughout the characterization process the MDMSC TI-ES team was treated courteously by the ALC management and line workers. The coordination and support from MAWF reflected a cooperative team commitment and was key to successfully concluding the data collection process on schedule. The product of this program is the result of a concerted effort by MDMSC and SA-ALC personnel.

8.1 MABPSA ANALYSIS AND FOCUS STUDY RECOMMENDATIONS

MABPSA is the Wing and Surface Unit Resource Control Center (RCC) within the Aircraft Division (MAB) Component Repair Section (PS). It is responsible for repairing B-52 flaps, spoilers, elevators, rudders, doors and hatches, and C-5 pylon aprons.

The current processes, facilities, equipment, and manpower found in this RCC are described in paragraphs 8.1.1.1 through 8.1.1.4. A description of the statistical experimentation is contained in paragraph 8.1.2.

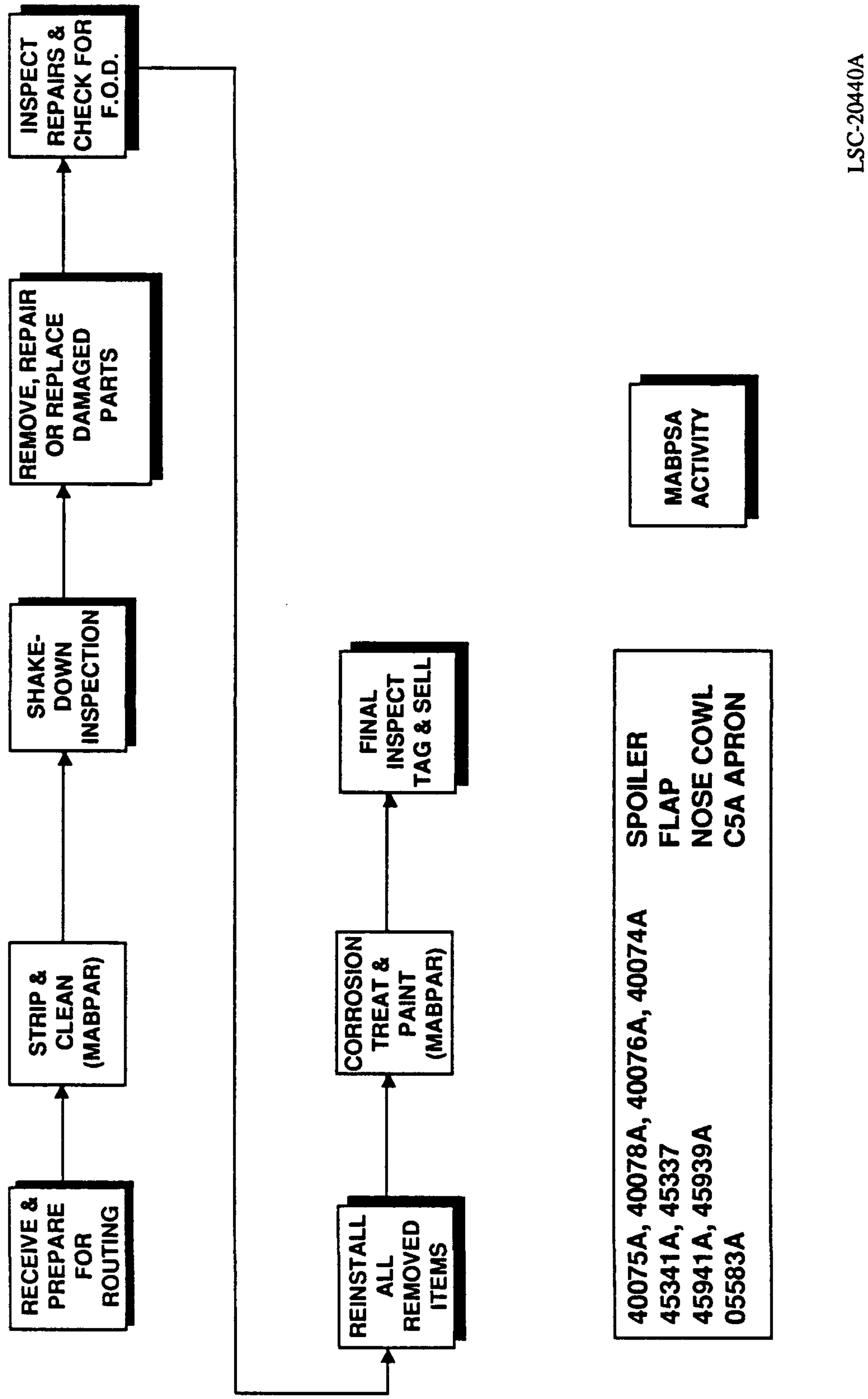
8.1.1 Description of Current Operations

This paragraph summarizes the engineering assessment of the As-Is conditions within MABPSA. Where appropriate, it includes MDMSC recommendations for changes and identification of strong and weak points in the RCC's operation.

8.1.1.1 Current Processes

The primary workload of MABPSA consists of Management of Items Subject To Repair (MISTR). The 80/20 analysis performed for this RCC identified nine end items for characterization, including four spoilers, two flaps, two nose cowls, and one pylon apron assembly. During 1988, this RCC performed a substantial amount of temporary manufacturing work under the PACER LIGHT program. This additional workload is no longer performed in MABPSA and, after consultation with RCC supervision, was not included in the characterization. As the MISTR workload has changed very little since 1988, the workload reflected in the model represents a realistic baseline of 80% of MABPSA work. Manpower and equipment were adjusted accordingly in the model, as described in paragraphs 8.1.1.3 and 8.1.1.4.

MABPSA is responsible for general repair/overhaul of sheet metal control surfaces from the B-52 and C-5A aircraft. The parts are received from MABPAR stripped and cleaned. MABPSA performs inspection, disassembly, repair, and reassembly. MABPSA performs no painting, NDI, or original manufacture of any sheet metal parts. The most common cause of repair on the parts received is corrosion. A typical process flow is shown on Figure 8.1.1-1.



TYPICAL PROCESS FLOW FOR MABPSA
FIGURE 8.1.1-1

The current repair process consists of visual inspections and manual repairs with hand tools. The work is labor-intensive and calls for substantial experience in the work force. Material handling is normally performed by the mechanics themselves. Given the large number of mechanics available, this does not present a serious problem but, in MDMSC's experience, is an unusual practice. Both MDMSC and most major airlines use specially designated material handlers for these tasks, saving the trained mechanics for the actual repair work. This situation is made even more pronounced in MABPSA by the size of many of the parts. Often two or more mechanics are needed to move a large part.

Spoilers are disassembled, one or both skins removed, and the ribs and other parts are inspected and repaired as required. Major repair involving reassembly of ribs, fittings, and top skin is accomplished using an alignment fixture. Minor repair and assembly of the lower skin is done on the work bench and in a holding fixture. The holding fixture used is a movable stand which holds the spoilers upright for ease of access. The spoiler area uses electric power cords and airhoses dropped from overhead lines to power the tools for assembly operations.

Flaps are received on movable stands from paint stripping and cleaning. The flaps are inspected by MABPSA for any skin damage. Access hole covers are removed and the flap interior is inspected for damage and corrosion. When required, skins are removed for whatever repair is needed. New skins are fabricated using the old skin as a template. New access holes are cut out by hand.

8.1.1.2 Facilities

MABPSA repair area occupies approximately 47,000 sq. ft. located in Building 375. The facility layout drawings provided to MDMSC were not current and had no signatures or any indication of recent updates. Hand sketches of the actual current layout were made by MDMSC engineers and may be found in Section 1 of the DDB.

The floor space allocated to MABPSA appears adequate and no process problems are caused by facilities design. The very large numbers of mechanics and parts, moving freely throughout the area made it very difficult for MDMSC to assess actual flows through the area. This is further addressed in paragraph 8.1.3.

All stripping and cleaning is performed in a back shop. Although a stripping facility exists in Building 375, B-52 nose cowls are moved to Building 385 for stripping. This is addressed as an observation in paragraph 8.1.4.

The environment throughout MABPSA is hot and humid, with high noise levels. It is difficult to quantify the effects of this environment, but they certainly include increased stress and lowered productivity.

8.1.1.3 Equipment

The bulk of the equipment used in the disassembly-repair-assembly process consists of various holding fixtures and a broad assortment of powered and non-powered hand tools. The fixtures are old (many 20-30 years) but are adequate to meet all current and projected workloads including war time surge. Their utilization rates are generally lower than those found in other areas of the RCC. The most heavily utilized fixture (according to the UDOS 2.0 model analysis) is an SA-12 flap dolly used 27% of the time. This is typical of a repair operation of this type, where a set of fixtures must be maintained for each PCN, regardless of utilization rates. Under simulated war time surge conditions, no piece of equipment was used more than 50% of the available time.

The hand tools, though not specifically modeled on UDOS 2.0, do not appear to cause a problem in the production process. No queues or bottlenecks were observed by MDMSC engineers that could be attributed to hand tools. MDMSC did note, however, a heavy volume of mechanic's complaints regarding the quality of the tools provided, and their state of wear. While higher-quality tools should be expected to produce some improvement in the process, the lack of quantifiable data, coupled with the relative unimportance of operation times (as described in paragraph 8.1.2.1) does not allow MDMSC to recommend changes

in the current hand tools. The only exception to this is the use of cobalt drill bits as described in paragraph 8.1.4. The relatively widespread worker dissatisfaction with hand tools should not be dismissed, however. MDMSC recommends this topic be a subject for a worker-conducted process improvement team study, under the QP4 program.

While MABPSA makes some use of powered material handling equipment (forklift trucks and overhead cranes) most parts are moved on rolling stands/dollies powered by WG-10 mechanics. The size of these parts often demands two or more workers. Most movements occur between MABPSA and a back shop. As a result, mechanics are often tied up moving parts, rather than repairing them.

MDMSC concludes that the equipment in MABPSA is sufficient for all current and projected needs and does not recommend the procurement of any additional equipment beyond that mentioned in this paragraph. The equipment reflected in the UDOS 2.0 model for this RCC is current as of 1989. No significant changes in equipment status have occurred since 1988.

8.1.1.4 Personnel

MABPSA currently employs 119 mechanics, under the supervision of seven supervisors. While these mechanics are divided into several wage grades, there is a great deal of interchangeability among them. These workers are generally skillful and the experience level is high (a typical situation throughout the command). The quantities reflected in the UDOS 2.0 model represent the current work force (1989) rather than the 1988 work force. This was done to correct for the elimination of 1988 PACER LIGHT workload and to produce a more realistic As-Is baseline.

MABPSA appears to have more than enough workers to meet its requirements. According to the UDOS 2.0 model, most workers are utilized less than 30% of their available time. This is confirmed by MDMSC observations of workers idled or directed to non-production tasks more frequently than in other RCCs. Mechanics often spend a great deal of time transporting parts, or performing

similar tasks because there was nothing else for them to do. While they do have a tendency to induct more work (producing the over-induction and elevated levels of Work In Process (WIP) identified in virtually every other RCC in this report), floor space and aircraft PDM schedules limit their ability to remain active through this technique. As a result a Parkinson's law effect appears to have set in, causing simple tasks to consume large amounts of time. It should be noted that neither the workers nor the supervisors in MABPSA are lazy or avoiding work. The problem lies in the labor force and workload levels currently set. This situation is addressed in detail in the experiments performed in paragraph 8.1.2.3, including recommendations for correction.

Currently, the bulk of the workers in MABPSA are assigned to the first shift. This tends to exacerbate the problem of under-utilization. The experimentation described in paragraph 8.1.2.3 illustrates the advantages of a three shift operation. On three shifts, overall utilization increased by almost 100%, with a corresponding decrease in flow time and WIP.

8.1.1.5 Explanation of Current Success

MABPSA is currently meeting all production requirements. This success is due largely to two factors:

- The existence of a very large work force of trained sheet metal repair mechanics.
- The relative simplicity of the repair process itself.

The large number of available workers virtually eliminates any of the queuing or delays normally found in other RCCs. The repair process itself is quite straight forward, requiring only standard hand tools, skilled workers, and some special fixtures (which are in adequate supply as well). As a result, large surges in workload can be handled by MABPSA with little increase in flow time, by simply assigning more workers to the new workload. This makes MABPSA extremely robust regarding shifts in workload, but at a high cost. Under current and projected conditions (including war time surge) the work force in MABPSA is roughly 20% higher than required to meet production needs. This is discussed in detail in paragraph 8.1.2.3.

The most significant weakness in the MABPSA process is the dependence on back shops, particularly MABPAR, for stripping, cleaning, and painting. With the exceptions of the nose cowls, all the parts characterized spend between 30% and 60% of their total flow time in a back shop. Ninety percent of this time is in MABPAR. As MABPAR was not characterized in this Task Order, MDMSC engineers could not determine exactly why parts spend so much time there. A brief assessment, performed as part of the preparation effort for another task order, did show the existence of substantial queues in MABPAR. MDMSC recommends that MABPAR be considered for process characterization in future work, as any improvements there will substantially benefit MABPSA as well. MDMSC does not recommend the installation of stripping/cleaning/painting facilities in MABPSA at this time. The environmental and safety considerations would tend to make this extremely expensive, and difficult to justify. Further discussion of this situation is included in paragraph 8.1.3.

8.1.2 Statistical System Performance Measure

A joint MDMSC/SA-ALC team met 24 July - 3 August 1989 to validate all Block II and III UDOS 2.0 simulation models, including MABPSA. This was accomplished by comparing simulated flow times and throughputs to historical data, G019C standards data, and MABPSA supervisory estimates. Other areas, such as process flow, resource utilization, and location of queues were examined as well, in accordance with the UDOS 2.0 acceptance test procedure previously delivered. Details of the validation can be found in the validation meeting minutes and in section 8.0 of the MABPSA DDB.

A common brainstorming session for all Block II and Block III RCCs was conducted at the conclusion of the validation. The ideas collected were reported in Appendix A of the validation minutes. The Taguchi orthogonal array and the experimentation were completed by MDMSC in St. Louis. Results of the validation are discussed in detail in section 8.0 of the DDB for MABPSA.

During the brainstorming session, the bulk of the significant factors identified for experimentation involved a potential reduction in operation times for processing all PCNs. During the MDMSC analysis of the validated model output, however,

other significant areas for investigation were identified. As a result, two areas of experimentation were selected for this RCC. The first, described in paragraph 8.1.2.2 examines the effects of improved operation flow times by conducting multiple experimental runs at various levels of improvement. The second, described in paragraph 8.2.2.3 uses a Taguchi L_4 orthogonal array and conducts multiple experimental runs to evaluate the effects of changes in manpower levels, equipment quantities, and shift schedules. Because of the dissimilarity between the types of changes examined, it was necessary to conduct separate experiments in these areas.

8.1.2.1 Statistical Analysis of Current Conditions

The current configuration of MABPSA produces an average throughput (number of parts out/number of parts in x 100) of 89% when modeled on UDOS 2.0 (see Table 8.1.2.2-2 Experiment #1). Throughput by PCN ranges from the 40075A spoiler (113%) to 45941A nose cowl (53%). The primary cause for a throughput less than 100% is the WIP limits caused by the size of many of the parts. Nose cowls in particular are affected by this.

Equipment utilization is very low with most fixtures used between 2-20%. The highest utilization was the nine SA-12 flap dollies at 27%. This low utilization rate is driven by the extreme specialization of these fixtures (most are designed for a single PCN) and does not indicate the existence of excess equipment. Under surge conditions, the utilizations increased but no fixture was ever used more than 50% of the available time.

Manpower utilization for the primary skill areas (D05, 8, and 10 sheet metal mechanics) ranged from 12 to 37% on first shift and 81 to 96% on second shift. Only 17% of the mechanic work force is currently assigned to second shift. These utilization figures do not include time spent on indirect activities (clean-up, ordering parts, etc.) but do include average time lost to vacations, sick leave, training, and the 20% workload not modeled. This low utilization appears to be a case of too many workers on an inefficient schedule. Paragraph 8.1.2.3 describes this situation in greater detail.

There are no significant bottlenecks in the MABPSA process flow. There are no significant queues (except for large parts waiting to enter the RCC) or delays for any PCNs. The two nose cowls spend an average of 13.5% of their time waiting in queues. All other PCNs spend less than 7% of their flow time in queues. This is substantially lower than in most other RCCs studied under Task Order No. 1. These figures do not include delays caused by parts shortages. Only slight increases in queue times occurred under surge conditions.

Most parts spend 30-60% of their time in back shops, primarily MABPAR. The only exceptions are the 45939A and 45941A nose cowls, which spend less than 10% in back shops. This situation is discussed in more detail in paragraph 8.1.2.2 and 8.1.3.

8.1.2.2 Area 1 Experimentation - Operations Improvement

Brainstorming was conducted in one session for all four Block II and Block III RCCs. The bulk of the ideas generated for experimentation affect the length of time it would take to perform the operations in the RCCs. These ideas were presented in broad terms and included:

- Age of equipment - if newer, more effective equipment were available, operation times could be shortened.
- Quality of equipment - if the equipment that were purchased were of a better quality, operation times could be shortened.
- Newer and better hand tools - the same arguments for equipment apply for hand tools
- Better selection of personnel - if new hires were more trainable for their positions, the length of time it takes to perform operations would be shortened. It was felt that the quality of incoming personnel was not what it should be.

As only rough estimates of the effect of each idea were available, it was decided to test the overall effects of reduced operation times on the RCC. A set of experiments was run with all of the operations reduced by a specified percentage. The purpose of these experiments was to see if the reduction would have a large effect on the flow times for the RCC. If there was a large

effect, then it would be worthwhile to set as a goal an overall reduction in operation times. If the reduction in flow times was not significant enough to warrant the investment required to reduce the operation times, then other areas, such as back shop times could be investigated.

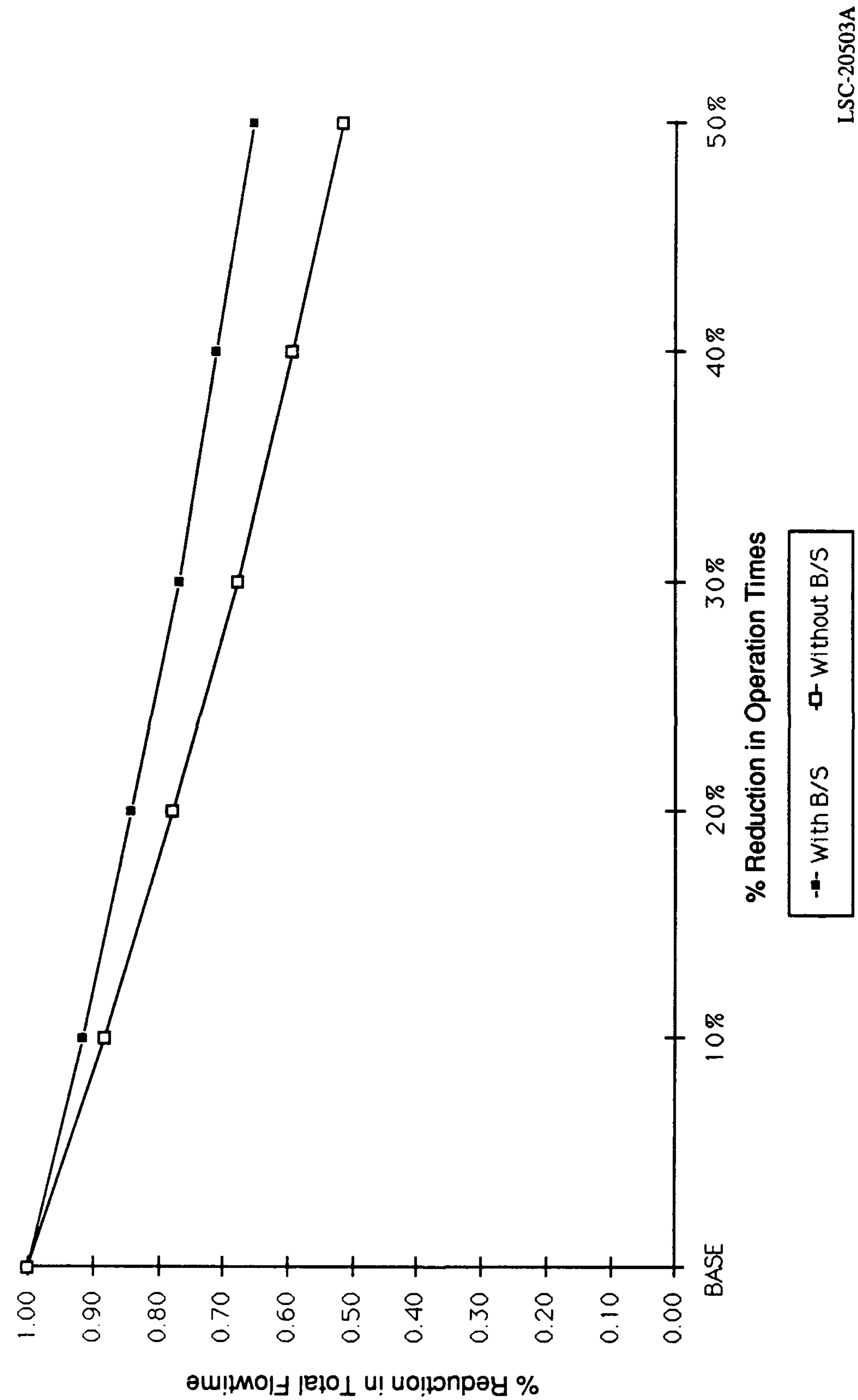
The experimentation was set up to compare the flow times from six runs. The descriptions of the runs are:

- The Baseline data.
- The Baseline with all processing operations reduced by 10%.
- The Baseline with all processing operations reduced by 20%.
- The Baseline with all processing operations reduced by 30%.
- The Baseline with all processing operations reduced by 40%.
- The Baseline with all processing operations reduced by 50%.

Tables showing a summary of the flow times by item and average back shop hours are shown in the Experimentation Section of the MABPSA DDB. A total flow time for the RCC was calculated and a percentage reduction from the baseline was calculated for each run. A similar calculation was made with the back shop times excluded from the flow times. These results are also shown graphically in Figure 8.1.2.1-1, and in table form in the Experimentation section of the MABPSA DDB.

The results indicate an approximately linear reduction in flow times with the corresponding reduction in operation processing times. The reduction in flow times is the result of shorter operating times and smaller queue times. Since none of the items showed significant queue times to begin with, the linear reduction is not surprising.

Back shop times for items, 40075A, 40076A, and 40078A are approximately 60% of the flow time and for item 05583A approximately 40% of the overall flow time. Concentrating on reducing the back shop flow times [notably MANPAR, the paint shop] would be a better approach for reducing overall flow times. Since many RCCs send items to MANPAR, any improvement in its flow times will affect many RCCs.



EXPERIMENTATION WITH REDUCED OPERATION TIMES
% OF BASE FLOW TIMES FOR MABPSA
FIGURE 8.1.2.1-1

8.1.2.3 Area 2 Experimentation with Taguchi Methodology Under Normal Workload

The array selected for experimentation was an L_4 Taguchi orthogonal array with three factors at two levels each. The array is shown in Table 8.1.2.2-1. Four experimental model runs were performed by MDMSC under normal workload for this RCC. The simulated average flow times and throughputs were collected and analyzed for each of the nine PCNs characterized in MABPSA. The detailed analysis sheets are included in section 10.0 of the DDB for MABPSA. An overview of the throughput results is summarized in Table 8.1.2.2-2. The conclusions reached from analysis of the normal workload experiments are as follows:

- MABPSA has sufficient capacity to meet normal workloads. The average model throughput for the RCC was never below 100%. There are no significant bottlenecks in the process flow through this RCC.
- Factor A (changes in manpower levels) and Factor B (changes in equipment levels) produced little effect for any PCN. All responses, for both flow time and throughput, showed less than 3% change, with most less than 1%. The changes showed no identifiable pattern. This indicates that this RCC has more manpower and equipment than is currently required. By reducing manpower roughly 20% and producing no change in output, MDMSC concludes that 20% of the current MABPSA work force can be made available for other work. The addition of equipment in the model produced no change in output. An examination of utilization rates indicates that there are no equipment bottlenecks in MATPSA and, in fact, utilization is much lower overall than that found in other areas of the ALC.
- Factor C (changes in shift schedules) showed a significant effect for all PCNs. Placing all personnel on three equally-sized eight hour shifts produced an average 19% decrease in flow time. The least improved PCN was 40075A at 10%, and the most improved was 45337A at 26%. Throughput increased an average of 15%. Shift schedules for back shops were not changed in this experiment.

MABPSA L_4 TAGUCHI ORTHOGONAL ARRAY

TABLE 8.1.2.2-1

NORMAL WORKLOAD

RUN	A MANPOWER	B EQUIPMENT	C SHIFT WORK
1	AS-IS	AS-IS	AS-IS
2	AS-IS	ADDITIONAL EQUIPMENT	3 SHIFTS
3	REDUCED	AS-IS	3 SHIFTS
4	REDUCED	ADDITIONAL EQUIPMENT	AS-IS

SURGE WORKLOAD

RUN	A MANPOWER	B EQUIPMENT	C SHIFT WORK
1	AS-IS	AS-IS	2 12-HOUR SHIFTS - 7 DAYS

REDUCED MANPOWER = - 6 3806SD05s
- 6 3806SD08s
- 8 3806SD10s

ADDITIONAL EQUIPMENT = + 2 SA-12s
+ 2 SA-14s
+ 1 SA-15s
+ 2 SA-2s
+ 2 SA-7s

LSC-20505

MABPSA $L_4(2^3)$ TAGUCHI ORTHOGONAL ARRAY THROUGHPUT EXPERIMENTAL RESULTS - FY 88

TABLE 8.1.2.2-2

EXP #	MANPOWER ASSIGNED	EQUIPMENT QUANTITY	SHIFT WORK	NORMAL WORKLOAD		
				AVG	BEST	WORST
1	AS-IS	AS-IS	AS-IS	89 %	40075A / 113%	45941A / 53%
2	AS-IS	ADD EQUIPMENT	3 SHIFT	104 %	40075A / 109%	45337A / 88%
3	REDUCED	AS-IS	3 SHIFT	104 %	40075A / 109%	45337A / 88%
4	REDUCED	ADD EQUIPMENT	AS-IS	89 %	40075A / 113%	45941A / 58%

				SURGE		
SG1	AS-IS	AS-IS	12-HOUR SHIFTS	102 %	45939A / 112%	45337A / 78%

LSC-20504

- Factor C also produced an average 60% reduction in the amount of work-in-process inventory. Half of this reduction was produced by two PCNs--45941A and 45939A. Maximum work-in-process limits were placed on the first shift experiments to simulate RCC floor space limits (these parts are very large). So, parts waiting outside the RCC were included in these calculations as well. Using the acquisition cost of the end items in this inventory, the dollar value of the inventory reduction is estimated to be $4,184,520. Of this, $3,738,000 is from reductions in PCNs 45941A and 45939A (B-52 nose cowls).
- While interactions were not specifically modeled, MDMSC experience with other RCCs indicates that no significant interactions should be expected.

8.1.2.4 Experimental Results Under Surge Conditions

An additional run was made under war time surge workload conditions using induction data provided by HQ AFLC. The conclusions drawn from the MDMSC analysis of this experiment are as follows:

- MABPSA has sufficient resources to meet war time surge requirements. Using only existing resources, with all personnel placed on 12-hour shifts, seven days per week, the average throughput was 102%. The only PCN below 95% was 45337A at 78%. The primary cause of this loss of production was an extremely long (ten day) flow time through a back shop (MABPAR) for painting. No significant bottlenecks occurred within MABPSA.
- The current levels of manpower were retained for this experiment, but two 12-hour shifts were used to simulate a war time environment. The additional manhours this made available, coupled with better shift coverage, actually reduced average simulated flow times from their current levels. Work-in-process inventories also fell proportionately. Manpower utilization was high (87-98%) during the week but much lower on weekends. Manpower levels were not a significant bottleneck and could be reduced 10-20% without producing significant negative effects on production.

8.1.2.5 Conclusions and Recommendations

MDMSC concludes that MABPSA has an overabundance of workers and an inefficient shift schedule. The distribution of the work force across additional shifts will produce a more efficient utilization of manpower, drastically shorten flow times, and improve throughput. On any shift schedule, approximately 20% of MABPSA's current manpower can be released to other work without reducing total capacity below that required to meet current or projected production levels (including war time surge).

Those PCNs modeled spend 30-70% of their time actually being worked. Because the work involves minimal delays (the model does not include delays for parts, engineering assistance, or administrative delays) and no parallel operations, every minute reduced from an operation time results in a minute of reduced flow time. <u>There is no critical path in the flow</u>. This means that no area of operations should receive special management attention.

MDMSC offers the following recommendations to MABPSA management, based on the results of experimentation:

- MABPSA management should consider shift work to gain improvements in flow time and work-in-process inventories.
- No additional capital equipment should be purchased (for MABPSA) at this time.
- While reducing the time to perform operations would yield improvements in flow times, these improvements would not be dramatic. A better focus of management attention would be on back shop flow times, which currently make up as much as 65% of a part's total flow time. MABPAR, which is the single most significant back shop (over 90% of all back shop time is in MABPAR) should be the primary candidate for study, and should be considered for TI-ES process characterization in the future.
- The back shop flow times used in these experiments are based on peace-time workloads in the back shops. MABPSA management should work with the managements of MABPAR, MABPAC, MABPMF, and MAQCND to develop better estimates of flow times through these RCCs (using an integrated systems approach) under war time surge conditions.

- The experimentation results for MABPSB and MABPSP indicated that the performance of both would be improved by additional manpower (especially MABPSB). Recommend five to seven sheet metal workers, at various skill levels, be cross-trained from MABPSA activities to those found in MABPSB and MABPSP. An excellent long-range strategy would be to develop a large pool (60-70% of total work force) of cross-trained workers who can be moved freely between these RCCs. This will allow better utilization of the work force and make each RCC's production more robust to changes in workload, including war time surge.

8.1.3 Description of Process Problems

MABPSA has no obvious process problems. Overall capacity, given the abundance of manpower and equipment, appears to exceed even projected surge workloads by 20-25%. The processes are simple manual repair operations with little interaction and no critical path. Actual "acceptable" flow times are determined by the requirements/schedule of the aircraft PDM line(s) supported by MABPSA. Without an assessment of these lines, MDMSC cannot provide a realistic assessment of the importance of a flow time through the RCC. While personnel in the RCC complained of parts shortages, MDMSC was unable to identify any situation where aircraft were delayed because of a delay in MABPSA. Two problems were identified, however, in the management of MABPSA's production process.

The first problem was in the amount of time parts spent in MABPAR as a back shop. It appears that 30-60% of the total flow time through MABPSA is not under the control of MABPSA management. This severely limits the ability of the MABPSA work force to implement process improvements. MABPAR appears to be a more rewarding candidate for process characterization than MABPSA.

The second problem is a common one throughout the command. Actual data on process times and flow times is seldom captured, and thus, cannot be used to manage the RCC or evaluate potential improvements. While the completion of each operation should be dated on the WCD attached to the part, this is

frequently overlooked by the mechanic. This lack of actual data makes it extremely difficult for MABPSA management to assess the impact of delays for engineering, supply, queuing, etc., or to quantify the cost of these delays. They can complain about problems, but they cannot provide the quantifiable data needed to justify a possible solution.

8.1.4 Other Observations

The other observations described in this section were not considered as focus studies or quick fixes because they had a less significant impact in the areas of time, quality, or cost. These observations are recorded to assist SA-ALC in developing ideas that will further enhance their operations.

These observations were originally identified as quick fix or focus study improvement opportunities and are detailed as such in the MABPSA DDB. After a review by the SA-ALC/MDMSC TI-ES team, it was mutually agreed that they should be presented as other observations for future reference.

In addition to these observations, additional general observations, process descriptions and other data can be found in section 2.0 of the DDB.

General Improvement Opportunities

- Review and Update Facility Layout Drawings
  - Current Condition: Building layout drawings are not current and do not reflect As-Is shop configuration. Drawings are not dated or signed. The engineering data block is devoid of entries. Drawings cannot be satisfactorily used for analysis or planning.
  - MDMSC Recommendation: Implement a standard review process for layout drawings, and update at least annually. Engineering data block should be completed and dated to determine valid date, change dates, approving authority, and engineering draftsman.

- Decrease Possibility of Error by Correcting Content and Sequence of Operations
  - Current Condition: Some WCDs (e.g. BE007E, BE009E) have operation steps out of sequence or missing. While WCDs are not detailed work procedures, they are still a guide to job execution, not merely a document for stamping off job completions.
  - MDMSC Recommendation: Implement a system for regular review of WCDs to ensure that necessary changes are incorporated, procedures are correct, are in the proper sequence, and key steps (requiring PAC stamp acknowledgment) are included. When done, mechanics will be less likely to overlook an important operation, or perform one incorrectly.
- Use Alternate B-52 Nose Cowl Strip and Clean Location
  - Current Condition: Most B-52 nose cowls (PCN 45939 and 45941) are stripped and cleaned in Building 385 before repair. This involves a move of over 200 yards each way to/from the repair area in Building 375.
  - MDMSC Recommendation: To the maximum extent practical, use the strip and clean facility in Building 375. This will reduce the move and handling time and decrease the potential for damage to the cowls that the longer trip to Building 385 involves. This will provide greater control of the product, less process flow time, and less labor time for transit.

- Change to Better Performing Drill Bits
  - Current Condition: The RCC is using a cobalt drill bit for making holes during repairs. These drill bits are not performing satisfactorily as they become dull too rapidly. Dull bits "walk" when starting and produce poor quality holes.
  - MDMSC Recommendation: A titanium-coated drill bit should be used. These bits are longer lasting and better performing than the regular cobalt bit. They increase productivity and produce better quality holes.

- Punch Access Holes in Skins
  - Current Condition: When an old skin is removed, a new skin is made using the old skin as a template. New access holes are manually sawed out and then hand filed.
  - MDMSC Recommendation: Provide a small punch press and die to prepunch the access holes in the skins at the mechanic's workstation. This would reduce the manual labor needed in the fabrication of the skins and increase uniformity and accuracy of the holes.

8.2 MABPSB ANALYSIS AND FOCUS STUDY RECOMMENDATIONS

Resource Control Center (RCC) MABPSB is responsible for overhauling the C-5A engine inlet cowl, the B-52 engine cowl assemblies, and B-52 wrap panels.

The current processes, facilities, equipment, and manpower found in this RCC are described in paragraphs 8.2.1.1 through 8.2.1.5. A description of the statistical analysis and experimentation is contained in 8.2.2.

8.2.1 Description of Current Operation

This paragraph summarizes the engineering assessment of the As-Is conditions within MABPSB, including processes, facilities, equipment, and personnel. Where appropriate, it includes MDMSC recommendations for changes and identification of strong and weak points in the RCC's operation.

8.2.1.1 Description of Current Operations

The primary workload in MABPSB consists of Management of Items Subject To Repair (MISTR). The 80/20 analysis was performed using data from the G019C report and identified eight items for process characterization, including one C-5A cowl assembly, one B-52H wrap panel, three B-52G cowl panels, and three B-52H side cowls. A comparison of the G019C and G004L reports revealed that MISTR items accounted for approximately 85% of the total RCC workload, with PDM and Temporary and Manufacturing (T&M) jobs accounting for roughly 2% and 13%, respectively. By analyzing only MISTR items, MDMSC actually modeled approximately 70% of the total MABPSB workload. To compensate for this, the manpower availability (the key resource in this RCC) in the UDOS 2.0 model was reduced accordingly. This produced a model with outputs that were acceptable to the ALC personnel on the validation team. Details of the workload analysis can be found in section 3.0 of the DDB.

MABPSB is responsible for general repair/overhaul of sheet metal surface parts for the C-5 and B-52 aircraft. The parts are received from MABPAR stripped and cleaned. MABPSB performs inspection disassembly, and repair/replacement, then returns the parts to MABPAR for corrosion treatment and painting. The painted parts are then returned to MABPSB for a final

alignment. A diagram of this process flow is shown in Figure 8.2.1-2. The complexity of the C-5A cowl assembly (PCN 01172A) requires additional back shop work and is illustrated separately in Figure 8.2.1-1. MABPSB performs no painting, NDI, or original manufacture of any sheet metal parts.

The repair operations are labor intensive with no automated equipment. Most operations are completely manual; only a few using pneumatic hand tools for drilling and rivetting. Most of the work is performed either in assembly jigs or in mobile work stands. These stands have castors and are used to transport assemblies within the RCC and to back shops. Assembly and alignment fixtures use manual screw clampings. The noise level in the RCC is very high. Pneumatic drills, rivet guns, and the process of bucking rivets into sheet metal create a loud, unbaffled clamor in the shop. More details of the processes used in MABPSB can be found in section 13 of the DDB.

8.2.1.2 Facilities

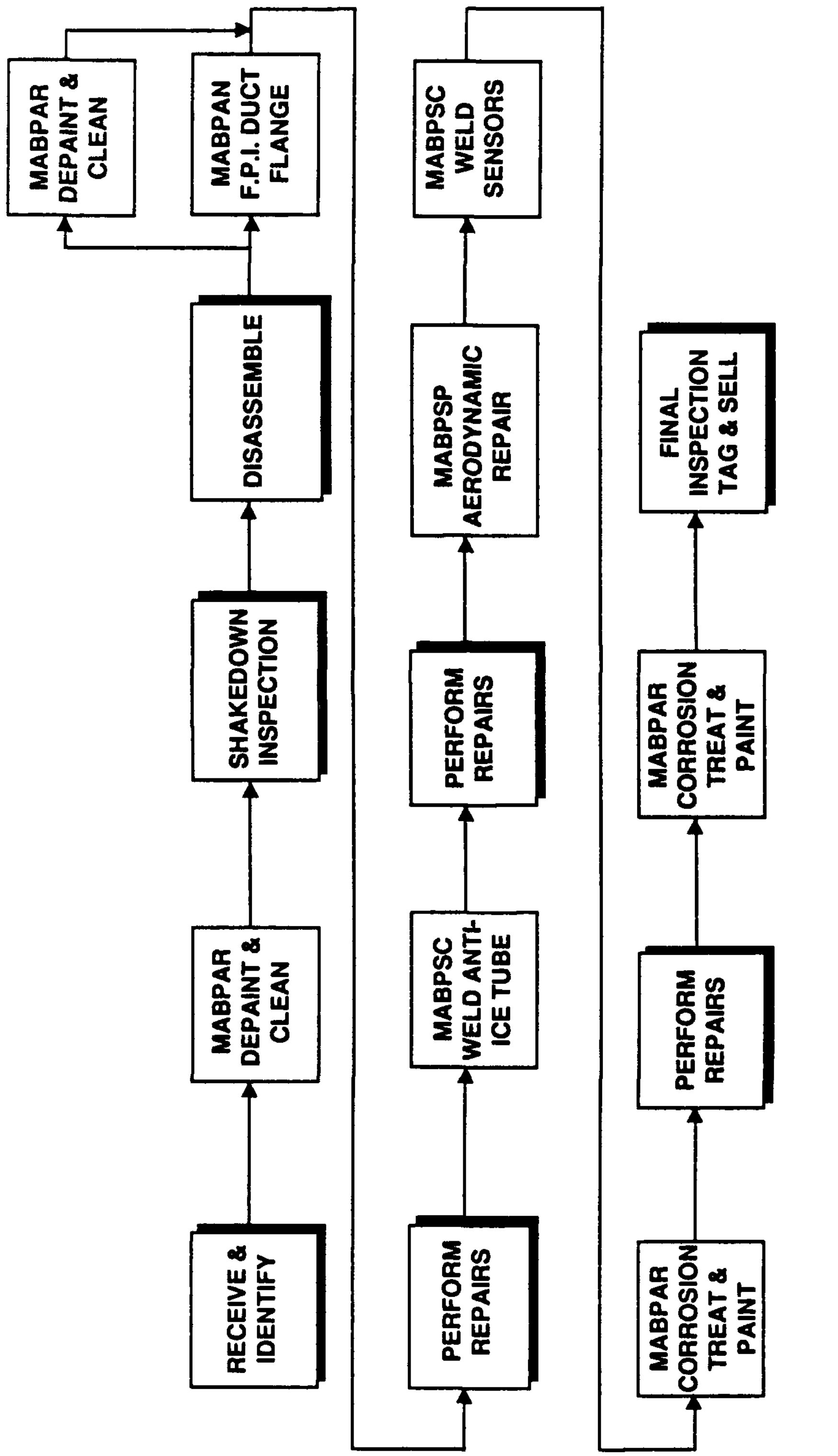
MABPSB occupies approximately 34,307 square feet of floorspace on the east side of Building 375. Each part-type is repaired in a separate section. The layout drawings provided to MDMSC were not current and had no signatures or any indication of recent updates.

The floorspace in MABPSB is crowded with Work In Process (WIP). The large size of most of parts makes this a significant problem as it requires a great deal of additional maneuvering and material handling to move parts out of one another's way. This is addressed in more detail in paragraph 8.2.3. Other than this crowding, no facilities-related process problems were observed by MDMSC.

The environment in the facility is hot and humid and loud enough to require earplugs. It is difficult to quantify the effects of this environment but they certainly involve increased stress and lowered productivity.

8.2.1.3 Equipment

The repair equipment in MABPSB consists primarily of various holding fixtures as well as a broad variety of powered and nonpowered hand tools. It also has

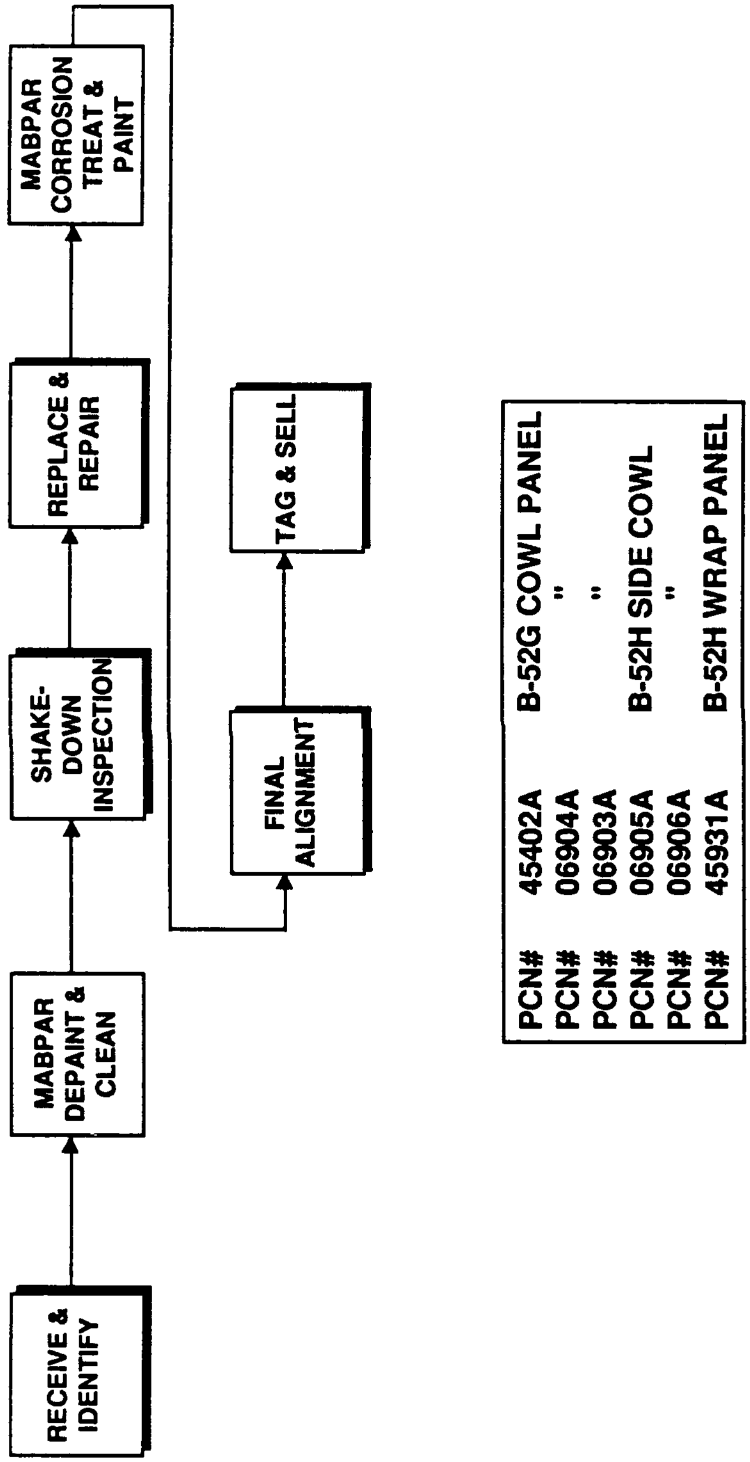


LSC-20441

PCN# 01172A C-5A COWL ASSEMBLY

MABPSB PROCESS FLOW 1

FIGURE 8.2.1-1



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MABPSB PROCESS FLOW 2
FIGURE 8.2.1-2

work stands, a band saw, a power shear, grinders, drill presses, and freezers. This equipment is kept clean and well maintained. A typical work station in MABPSB consists of a workbench, an assembly jig or work stand for the item to be overhauled, and a nearby cabinet for stored special tools.

This equipment is very similar to that used in the sheet metal repair centers of many major commercial airline repair facilities, including TWA and American Airlines. The only significant problem noted was the weight of the rivet guns used. These were heavy enough to cause worker fatigue and should be replaced with lighter models on an attrition basis.

Supervisors and workers throughout MABPSB complained of a lack of hand tools. While MDMSC did observe mechanics frequently searching for, or borrowing, hand tools, the high volume of WIP and the low level of available labor made it difficult to assess the real impact of the tool shortage. MDMSC recommends this problem be the subject of a worker-conducted process improvement study under the QP4 program.

Material handling equipment in the RCC consists of overhead cranes, rolling stands and dollies, and an occasional tug or forklift from another area. Parts are frequently pushed on a rolling work stand, by 2-4 mechanics, between MABPSB and back shops when a tug is not available. This causes occasional bottlenecks and is addressed in greater detail in paragraph 8.2.2.2.

8.2.1.4 Personnel

There are 119 sheet metal mechanics assigned to MABPSB: 49 WG-10 senior mechanics, 37 WG-08 mechanics, 29 WG-05 helpers, and four WG-00 trainees. Of these, 102 are on first shift and 17 are on second. The mechanics are very knowledgeable in sheet metal fabrication and repair, and are turning out quality products. Mechanics in MABPSB work primarily on one type or model of end item, but are cross-trained to work on various end items.

The UDOS 2.0 model, as well as MDMSC observations, indicates that the number of personnel assigned to MABPSB is insufficient to meet current or

projected taskings. The UDOS model shows manpower utilizations between 40-99% at current workloads. This is substantially higher than that found in most other RCCs throughout the command. The result is large queues of parts in-process throughout the RCC and an enormous volume of inventory. This problem is addressed in greater detail in paragraphs 8.2.2.3 and 8.2.3. The manpower shortage in this RCC is the single most significant bottleneck in the entire MABPSB production process.

8.2.1.5 Explanation of Current Success

MABPSB is currently meeting its production requirements, in spite of a manpower shortage. The primary source of this success is the presence of a large volume of WIP inventory which serves as a buffer stock between MABPSB and its aircraft customers. Using UDOS WIP reports and USAF acquisition costs for the nine PCNs modeled, MDMSC estimates the value of this inventory at approximately $4.7 million (not counting subassemblies or nonmodeled parts). This inventory buffers the effect of long flow times through MABPSB by insuring a steady supply of parts for aircraft use. It also obscures the real problem, making it difficult to gather the data needed to affect a long-term solution.

A second factor in the success of MABPSB is the ingenuity and skill of many of the workers. They have developed a variety of "work-arounds" to alleviate process problems such as the labor shortage. For example, as identified in paragraph 8.2.2.2, operations which require multiple workers are difficult to accomplish with such tight labor conditions. Operation 415 of WCD 003C for PCN 01172A (C5A cowl assembly) requires the part be turned over, using a sling and three mechanics, for stenciling. A common practice in the shop is for one mechanic to crawl under the part and stencil from below. This technique relieves a bottleneck and increases productivity. It also, unfortunately, hides the real problem and denies the planning function the information they need to improve the WCD. As identified in other RCCs, the strengths of inventory and worker innovativeness/skill are vital to the performance of the MABPSB process, with its current problems, but they hide the problem by treating its symptoms. This aspect is discussed further in paragraph 8.2.3.

8.2.2 Statistical System Performance Measure

A joint MDMSC/SA-ALC team met 24 July - 3 August 1989 to validate all Block II and III UDOS 2.0 simulation models, including MABPSB. This was accomplished by comparing simulated flow times and throughputs to historical data, G019C standards data, and MABPSB supervisory estimates. Other areas, such as process flow, resource utilization, and location of queues were examined as well, in accordance with the UDOS 2.0 acceptance test procedure previously delivered. Details of the validation can be found in the validation meeting minutes and in section 8.0 of the MABPSB DDB.

A common brainstorming session for all Block II and Block III RCCs was conducted at the conclusion of the validation. The ideas collected were reported in Appendix A of the validation minutes. The Taguchi orthogonal array and the experimentation were completed by MDMSC in St. Louis.

During the brainstorming session, the bulk of the significant factors identified for experimentation involved a potential reduction in operation times for processing all PCNs. During the MDMSC analysis of the validated model output, however, other significant areas for investigation were identified. As a result, two areas of experimentation were selected for this RCC. The first, described in paragraph 8.2.2.2, examines the effects of improved operation flow times by conducting multiple experimental runs at various levels of improvement. The second, described in paragraph 8.2.2.3, uses a Taguchi L_4 orthogonal array and conducts multiple experimental runs to evaluate the effects of changes in manpower levels, equipment quantities, and shift schedules. Because of the dissimilarity between the types of changes examined, MDMSC elected to separate the experiments into two areas.

8.2.2.1 Statistical Analysis of Current Conditions

The current configuration of MABPSB produces an average throughput (number of parts out/number of parts in x 100) of 100% when modeled on UDOS 2.0 (see Table 8.2.2.2-1 Experiment #1). Throughput by PCN ranges from the 45402A B-52G cowl panel (112%) to the 45757A B-52H side cowl (92%).

MABPSB L_4 TAGUCHI ORTHOGONAL ARRAY THROUGHPUT EXPERIMENTAL RESULTS - FY 88

TABLE 8.2.2.2-1

EXP #	A MANPOWER	B EQUIPMENT	C SHIFT WORK	NORMAL WORKLOAD AVG	NORMAL WORKLOAD BEST	NORMAL WORKLOAD WORST
1	AS-IS	AS-IS	AS-IS	100 %	45402A / 112%	45757A / 92%
2	AS-IS	ADDITIONAL EQUIPMENT	3 SHIFTS	104 %	45931A / 113%	45402A / 90%
3	+6 TRAINEES	AS-IS	3 SHIFTS	105 %	45931A / 113%	45402A / 90%
4	+6 TRAINEES	ADDITIONAL EQUIPMENT	AS-IS	105 %	01172A / 112%	06906A / 90%
BEST	+6 TRAINEES	ADDITIONAL EQUIPMENT	3 SHIFTS			

				SURGE		
1	AS-IS	AS-IS	AS-IS	13 %	06906A / 73%	06903A / 0%
2	+6 TRAINEES	ADDITIONAL EQUIPMENT	3 SHIFTS	29 %	45931A / 103%	06903A / 0%

LSC-20518

Equipment utilization is rather low, with most fixtures used between 20-49%. The most heavily used fixture is the SB-6 work stand at 49%. This low utilization rate is caused by two factors: the specialization of many of the fixtures, and the shortage of manpower. The specialization is a common occurrence in repair operations of this sort and has been observed by MDMSC in other RCCs and in commercial repair centers. The labor shortage, however, is not so simple. Equipment appears to be underutilized because no one is available to use it. This is illustrated under the surge experimental runs on the UDOS model, where the number of parts in various queues increased dramatically, but equipment utilization only increased an average of 10-30%.

Manpower utilization for the primary skill areas (E05, 8, and 10 sheet metal mechanics) ranged from 40-99% on first shift and 98-99% on second shift, under current workload conditions. Only 13% of the work force is currently assigned to second shift. These utilization figures do not include the time spent on indirect activities (clean up, ordering parts, searching for tools, etc.) but do include average time lost to vacations, sick leave, training, and the 30% workload not modeled. This utilization is much higher than that observed in most other RCCs and appears to be the effect of too few workers on an inefficient shift schedule. Under surge conditions, all manpower utilization rates jumped to 100% on all shifts (workers were placed on 12 hour shifts around the clock) and large queues of parts built up throughout the shop.

The shortage of workers in MABPSB makes it very difficult to assess nonlabor driven bottlenecks. The processes are extremely simple, but very labor intensive. This means that equipment is generally under utilized, and work tends to queue for short periods at many operations, rather than at specific problem areas. Currently, parts are spending between 11-35% of their total flow time waiting in queues. Under surge conditions, this mushroomed to 40-90%, with output actually decreasing as parts clogged the RCC. This, coupled with current manpower utilization rates, leads MDMSC to conclude that MABPSB is currently operating at very near total capacity, with manpower as a general constricting resource. This is discussed in greater detail in paragraphs 8.2.2.3, 8.2.2.4, 8.2.2.5, and 8.2.3.

The UDOS model currently shows average flow times through MABPSB of 20-30 days. This time includes all back shop times (8-25% on the average) but does not include time spent awaiting parts, engineering assistance, or nonprocess related administrative delays. The historical average flow times through the RCC range from 50-85 days. Under surge conditions, UDOS flow times jumped to a range between 35 and 243 days. The increased variance is caused by an increasing sensitivity to process complication as workload increases. Parts with more complex processes, requiring more moves and handling, tend to form queues faster than parts with simpler processes. As workload increases, this effect becomes more pronounced. This is addressed in more detail in paragraph 8.2.2.2.

8.2.2.2 Area 1 Experimentation - Operations Improvement

A number of the ideas suggested for experimentation affect the length of time it would take to perform the operations in the WCDs. These ideas were presented in broad terms and included:

- Age of equipment - if newer, more effective equipment were available, operation times could be shortened.
- Quality of equipment - if the equipment that were purchased were of a better quality, operation times could be shortened.
- Newer and better hand tools - the same arguments for equipment apply for hand tools.
- Better selection of personnel - if new hires were more trainable for their positions, the length of time it took to perform operations would be shortened. It was felt that the quality of incoming personnel was not what it should be.

As only rough estimates of the effect of each idea were available, MDMSC decided to test the overall effects of reduced operation times on the RCC. A set of experiments was run with all of the operations reduced by a specified percentage. The purpose of these experiments was to see if the reduction would have a large effect on the flow times for the RCC.

The experimentation was set up to compare the flow times from six runs. The description of the runs are:

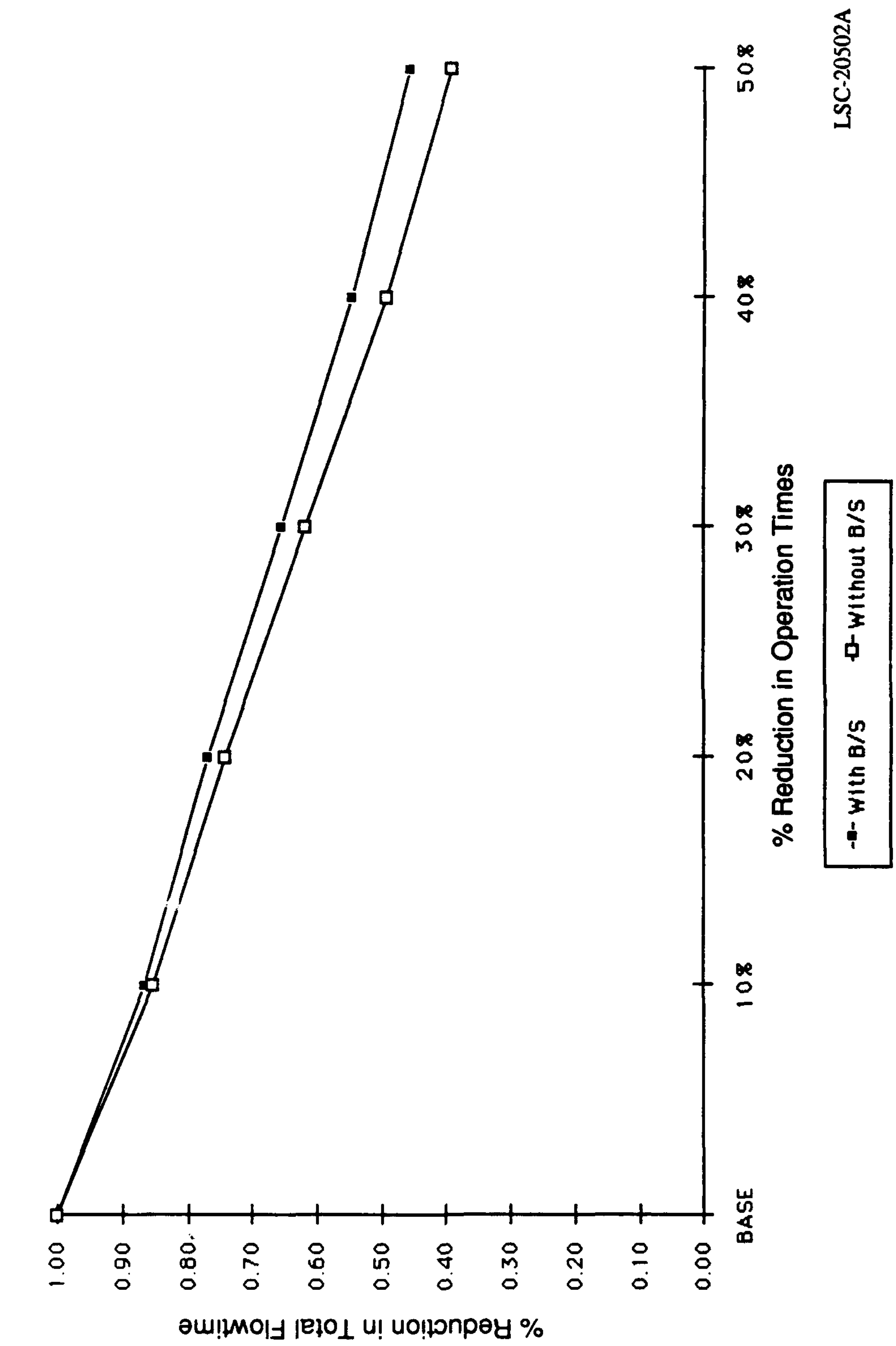
- The Baseline data.
- The Baseline with all processing operations reduced by 10%.
- The Baseline with all processing operations reduced by 20%.
- The Baseline with all processing operations reduced by 30%.
- The Baseline with all processing operations reduced by 40%.
- The Baseline with all processing operations reduced by 50%.

Tables showing a summary of the flow times by item, and average back shop hours are shown in the experimentation section of the MABPSB DDB. A total flow time for the RCC was calculated and a percentage reduction from the baseline was calculated for each run. A similar calculation was made with the back shop times excluded from the flow times. These results are also shown graphically in Figure 8.2.2.2-1, and in table form in the experimentation section of the DDB.

The results indicate an approximately linear reduction in flow times with the corresponding reduction in operation processing times. The reduction in flow times is the result of smaller operating times and smaller queue times. The largest reductions occurred in the 10% - 20% range.

A more detailed examination of the model experimental results at the 10% and 20% reduction levels indicates that certain operations produce a much larger share of the total improvement than do others. In particular, part handling operations (move, load, transport, etc.) and certain assembly steps show a pronounced effect.

The material handling steps frequently require more than one worker, for at least part of the time. Given the tight manpower situation in this RCC, reducing the amount of time required for these steps helps reduce both part-handling time and part-waiting time, providing a significant improvement in overall flow time.



EXPERIMENTATION WITH REDUCED OPERATION TIMES % OF BASE FLOW TIMES FOR MABPSB

FIGURE 8.2.2.2-1

The assembly operations require various subassemblies to complete. By decreasing operation times for these subassemblies, complete sets become available for assembly more quickly, thus reducing waiting times. The effect occurs, in the UDOS model, when all operation times are reduced. As it is unlikely that all operation times could be so reduced on the shop floor, this effect would be far less pronounced in the RCC than this experiment indicates.

8.2.2.3 Area 2 Experimentation With Taguchi Methodology

Using ideas from brainstorming, an L_4 Taguchi orthogonal array with three factors and two levels each was designed. The array is shown in Table 8.2.2.2-1. Four experimental model runs were performed by MDMSC using normal workload for MABPSB. The simulated average flow times and throughputs were collected and analyzed for each of the seven PCNs characterized in this RCC. The detailed analysis sheets are included in section 9.0 of the DDB for MABPSB. An overview of the throughput results is summarized in Table 8.2.2.2-1. The conclusions reached from analysis of the normal workload experiments are as follows:

- MABPSB currently has sufficient resources to handle normal workloads under the current configuration. Throughputs were acceptable for all PCNs, but flow times and work in process inventories were high.
- Factor A - Manpower, when increased by the addition of six trainees, produced an average 9% reduction in flow time and an average 15% increase in throughput. Manpower throughout this RCC is very critical and utilizations for all grades and skill codes (including the trainees) ranged from 85 to 95% on all shifts.
- Factor B - Equipment had only a minor effect on operations. The addition of equipment produced only an average 6% reduction in flow times and 2% increase in throughput. The effect on inventories was negligible. The equipment in this RCC is not a bottleneck at normal workloads.
- Factor C - Shift work had the single greatest effect on RCC operation. By putting the current work force on three equal shifts, flow times were reduced an average of 62% while throughput increased an average of 5%. Work in process inventories fell by an average of 38%, worth an

estimated $1,767,766 (based on average work in process by PCN multiplied by the Air Force acquisition cost). This was caused by reduction in inductions per shift (reduced batch size) and a better balance in line of flow.

8.2.2.4 Experimental Results Under Surge Conditions

Two surge experimental runs were made. One with the current baseline configuration and another with the best configuration of factors as shown in the Taguchi array. The results were as follows:

- MABPSB is unable to meet surge workload in its current configuration. The significant bottleneck under this configuration is manpower. All available workers are utilized at 100%, and the workload is still too great. Only an average of 13% of the required parts were produced.
- Back shop flow times are based on normal workloads rather than surge. Under wartime surge conditions, these flow times could be much longer than those reflected in this experiment.
- When the best configuration of factors was run under surge workloads, it performed better than the current configuration, but was still only able to produce an average of 29% of the required parts. This was caused by a severe shortage of manpower. Worker utilization (for all workers) ranged from 99 to 100%. Only those parts with fairly simple processes and relatively low induction rates (PCN 45931A and PCN 45757A) were able to flow successfully through the RCC.
- No significant bottlenecks were caused by equipment at either the As-Is or the Taguchi best configuration. The relatively heavy, consistent loading of certain fixtures (SB-5 and SB-6 work stands, the SB-7 sling fixture, and the SB-8 hoist adapter) indicates that they would become bottlenecks if additional manpower were added to the RCC.

8.2.2.5 Conclusions and Recommendations

MDMSC concludes that MABPSB has a significant shortage of workers and an inefficient shift schedule. The RCC is currently operating at very near total capacity, with unnecessarily long flowtimes and high levels of expensive WIP

inventories. This RCC would be unable to meet wartime surge demands without additional manpower.

The processes used in MABPSB are simple, with no parallel steps, thus no critical path exists in the RCC. The processes are quite labor intensive, however, and the tight manpower situation means that any operation which requires more than one worker will tend to develop queues and cause delays in the process. By placing the work force on shifts, a better, more balanced flow will result, with significant improvements in flowtimes and inventory levels. Shift work will reduce the cost of current operations, but will only improve total capacity 10-15%. This is not enough to meet the wartime surge demands projected by AFLC HQ.

MDMSC offers the following recommendations to MABPSB management, based on the results of experimentation:

- MABPSB management should concentrate on reducing/simplifying material handing steps that require more than one person. Use of additional material handling equipment (cranes, rolling fixtures, etc.) should be considered. Any improvements in these process times can be expected to produce a greater overall flowtime improvement than a corresponding improvement in other process times.
- If additional manpower is added to this RCC (recommended in paragraphs 8.1.2.2 and 8.2.2.3 of this report), at least one worker per shift should be dedicated to material handling. As this task requires very little skill, it may be rotated among apprentice/trainees.
- MABPSB management should work with the management of MABPSA to arrange the cross training of workers into the MABPSB process. A long term goal should be the formation of a pool of cross-trained sheet metal workers to support all MAB repair activities. This is discussed in paragraph 8.1.2.5.
- MABPSB management should immediately consider shift work for all workers to gain the benefits of improved flowtime and reduced inventory.

- MAB management should work with those RCCs which act as back shops for MAB parts to determine a realistic wartime surge plan that allows more accurate projections of flowtime through those RCCs.

8.2.3 Description of Process Problems

MABPSB suffers from a shortage of trained workers and an inefficient work schedule that causes unnecessarily long flowtimes through the RCC. The result of this is a large volume of WIP stored in queues throughout the RCC. This situation is made tolerable by the large amount of spares available to fill the pipeline through MABPSB. A more detailed description of this type of situation, and its effects, can be in paragraph 8.7.3.

The situation of tight manpower, coupled with a large inventory of production spares, acts to mask other problems. As described in paragraph 8.2.1.5, the work force is actively "working around" various problems, but has not successfully communicated the existence of these problems to their management. While MDMSC heard numerous complaints regarding such things as tool shortages and problems with supply support, no quantifiable assessment of the effects/costs of these problems could be produces. The heavy volume of WIP obscures process problems and buries the effects under an expensive mountain of inventory.

This problem is common throughout AFLC and in American industry in general. A recent MDMSC visit to a major U.S. airline revealed similar problems in the area of jet engine repair. The MDMSC recommended solution to this problem is the addition of workers to increase capacity, the use of shift work to reduce flowtime and a restriction on the total volume of WIP to eliminate the masking effect of excess inventory.

8.2.4 Other Observations

- C-5A Engine Cowl Delamination Inspection
  - Current Condition: The C-5 engine cowl has a small gap that is created by a sheet of metal on one side and an outside surface of the cowl honeycomb structure on the other side. A "coin test" is currently

used to determine if any refurbished/repaired honeycomb structure has successfully bonded to its two metal outer skins.

- MDMSC Recommendation: Conduct a search to determine if any suitable alternative delamination inspection methods are available at SA-ALC.

• C-5A Engine Cowl Panel Delamination
  - Current Condition: Engine mechanics are delaminating the honeycomb panels by stepping on the C-5A engine's cowl panels while repairing or removing the engine. MABPSB sheet metal mechanics report that 20% of the C-5A engine inlet cowl panels are received for overhaul or repair with one or more panels delaminated. MABPSB sheet metal mechanics are spending an estimated average 64 hours per panel to repair each cowl panel. This does not include material and bonding labor hours cost.
  - MDMSC Recommendation: Design a step that could be attached to a lift for use in the field as well as at the ALC. The bottom of the step should have the same radius as the inner diameter of the engine cowl. The bottom and the sides of the step should be foam padded to prevent damage to the panels' skin, should contact occur during engine repairs.

8.3 MABPSC ANALYSIS AND FOCUS STUDY RECOMMENDATIONS

MABPSC is the Manufacturing Resource Control Center Center(RCC) within the Aircraft Division (MAB). Late in 1988, a reorganization effort resulted in the combining of RCC MABPME, the Sheet Metal Manufacturing Unit, with portions of RCC MABPMF and the Alodine Line to create RCC MABPSC. SA-ALC requested that MABPSC be process characterized as two separate entities. To accommodate this request a RCC "MABWHT" was created for model purposes only. Thus, RCC MABPSC refers to the sheet metal manufacturing section and RCC "MABWHT" refers to the heat treating,welding,and alodine chemical processing section

The current process, facilities, equipment, and manpower found in this RCC are described in Paragraph 8.3.1.1 through 8.3.1.4. A description of the statistical experimentation is contained in paragraph 8.3.2.

8.3.1 Description of Current Operations

This paragraph summarizes the engineering assessment of the As-Is condition within MABPSC. Where appropriate, it includes MDMSC recommendations for changes and identification of strong and weak points in the RCC's operation.

8.3.1.1 Current Process

The workload of MABPSC consists of manufacturing, MISTR, PDM, and temporary. The sheet metal manufacturing section's effort is primarily manufacturing, producing parts needed to support the sheet metal repair shops and the aircraft lines. The welding, heat treat, and alodine section is a mix of the four types. The 80/20 analysis of the 1988 completions list provided by the SA-ALC found that (714) line items represented 80% of the sheet metal fabrication workload and (68) line items represented 80% of the welding and heat treat workload. One line item contained (184) detail parts.MDMSC and SA-ALC jointly decided that the 80/20 list could not be developed from the data provided, and that generic part numbers would be developed to represent the families of parts that flow through the shops. It was decided to group parts by families and characterize the process for a given family.

MDMSC, with the assistance of the planner for the sheet metal fabrication area and production personnel, developed eighteen families with their flow or Work Control Document (WCD). The listing of L3A-part numbers completed in 1988 was central to this effort and to determining the workload for each part number. The L3A listing represented 65% of the total effort of the area. The percentage of the total effort represented by each part (flow pattern) was determined and then multiplied by the total number of parts produced in 1988 to determine the total number of inductions for that part. See sections 2.5 and 3.1 of the DDB for more detail.

Eleven items in the welding, heat treat, and alodine area were selected for process characterization as representing approximately 80% of the normal workload; three items in heat treating, five items in welding, and three items in alodine processing. The workload was determined with the aid of the planner, engineer, and production supervisor of the area.

Most fabrication begins with sheet stock or extrusions. They are cut to size, formed,heat treated, straightened, trimmed, chemically treated, and painted. Each step can be accomplished using different methods, manual and machine. For example, a part can be cut to size using a band saw, hand shear, a blanking die on a punch press, or on a CNC router. A high percentage of the effort is manual. Parts are hand trimmed and sanded to size then manually formed using lead bars, raw hide hammers, or manually operated equipment.

The welding area repairs and manufactures parts to support the sheet metal repair RCC's maintenance and ground support. The processes used are arc welding, spot welding seam welding, and TIG welding. Heat treat's effort is primarily to heat treat, age, and stress relieve aluminum parts from the fabrication area.

The typical process flow sheets are shown in the following pages:

Sheet Metal Manufacturing	Figures 8.3.1-1 and 8.3.1-2
Welding	Figures 8.3.1-3 thru 8.3.1-5
Alodine Chemical Processing	Figures 8.3.1-6
Heat Treat	Figures 8.3.1-7

8.3.1.2 Facilities

The sheet metal fabrication area of MABPSC occupies approximately 23,000 sq. ft. of floor space. Of this total, approximately 12,225 sq. ft. is dedicated to the power equipment section and includes all of the power equipment, mechanics workbenches, office space, storage, and aisles. The remaining 10,875 sq. ft. is utilized by the majority of the mechanics' workbenches, small power equipment, layout mechanics area, offices, storage, and aisles.

During the equipment survey, the location of the equipment was recorded on the layout drawing provided by MABEA. This revealed that 61% of the equipment is located per the layout drawing but 39% of the equipment has been moved to different locations. This indicates that facilities engineers do not communicate often enough with production management or do not review layouts sufficiently often to maintain them. This layout is included in the DDB Section 2.0 (General Information), paragraph 2.1 (Facility Layout Drawing).

During interviews, MDMSC learned that the RCC rearranges the shop at their discretion without conferring with Facilities Engineering. This prevents layouts from ever being current. In most large industries, Facilities Engineering is responsible for developing equipment layouts to achieve best product flow and efficient utilization of equipment. This situation is discussed again in paragraph 8.3.3.

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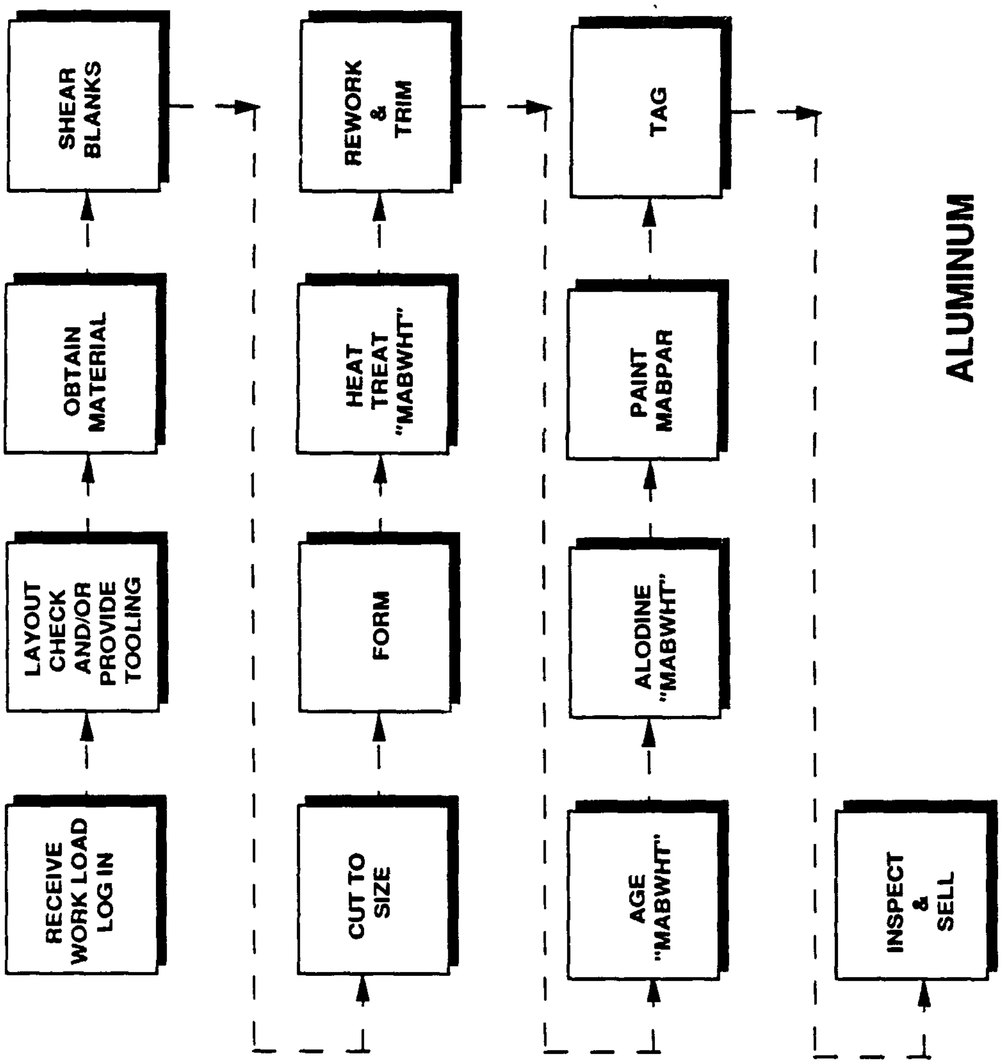

MABPSC TYPICAL PROCESS FLOW 1
FIGURE 8.3.1-1

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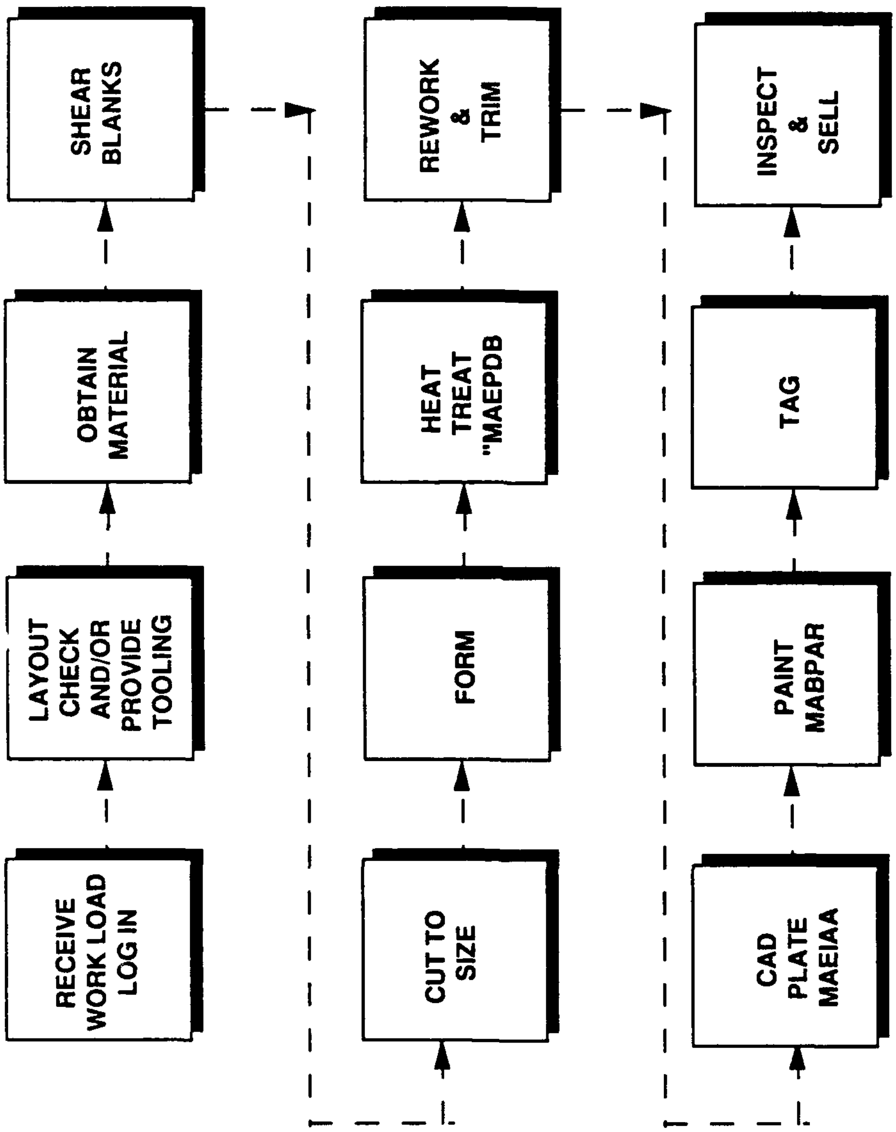

STEEL

MABPSC TYPICAL PROCESS FLOW 2
FIGURE 8.3.1-2

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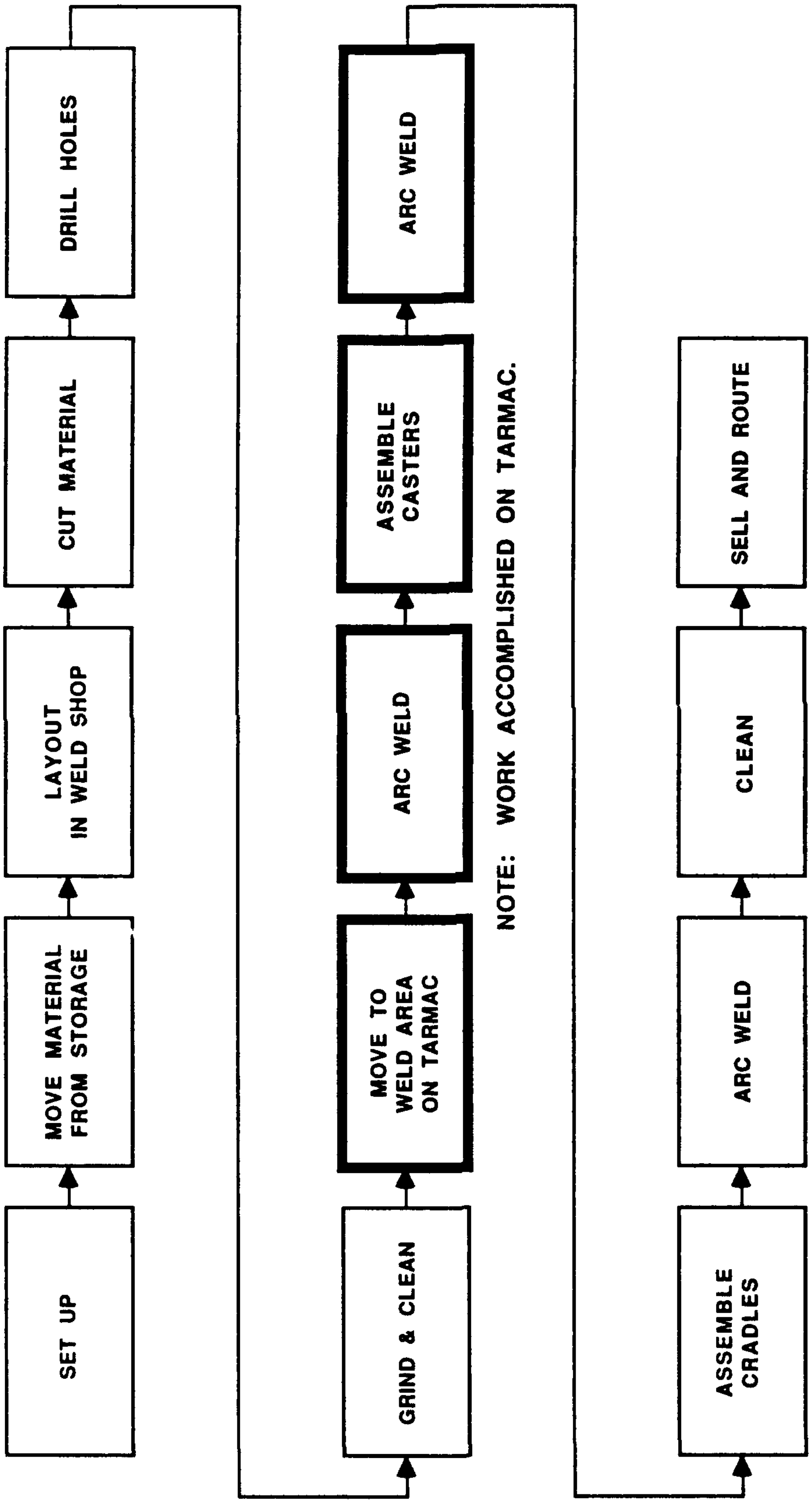
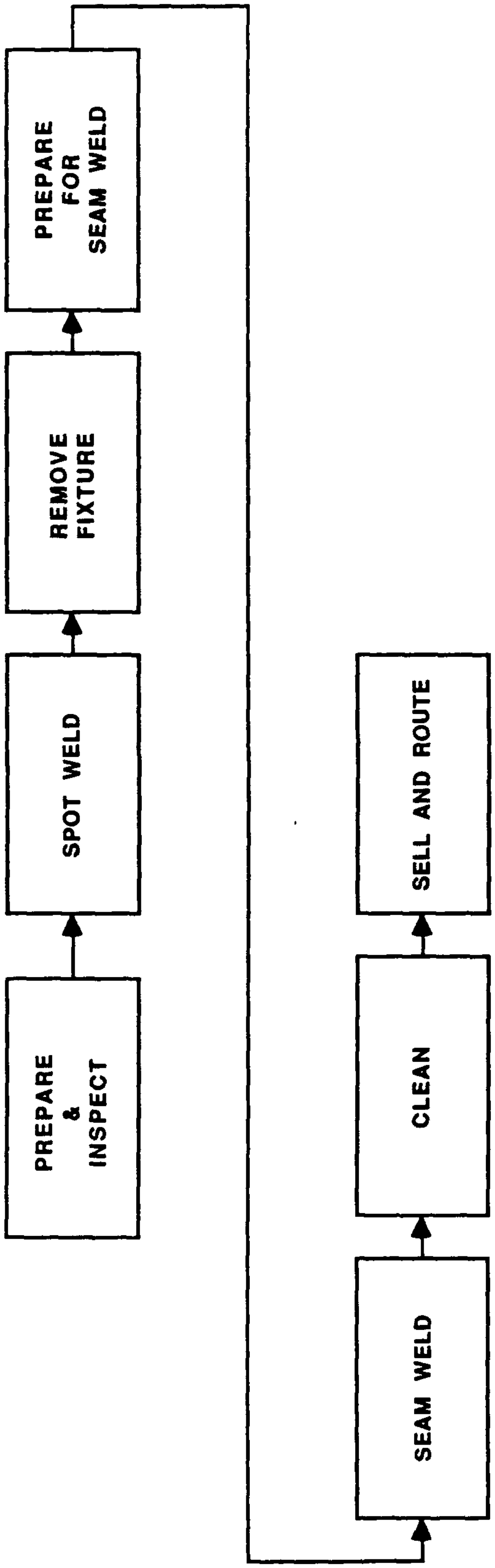


Example: B-52 Vertical Fin Transport Dolly

ARC WELDING FABRICATION PROCESS FLOW

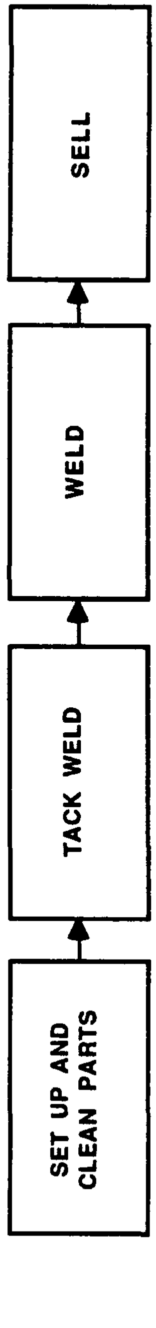
FIGURE 8.3.1-3

LSC-20225A

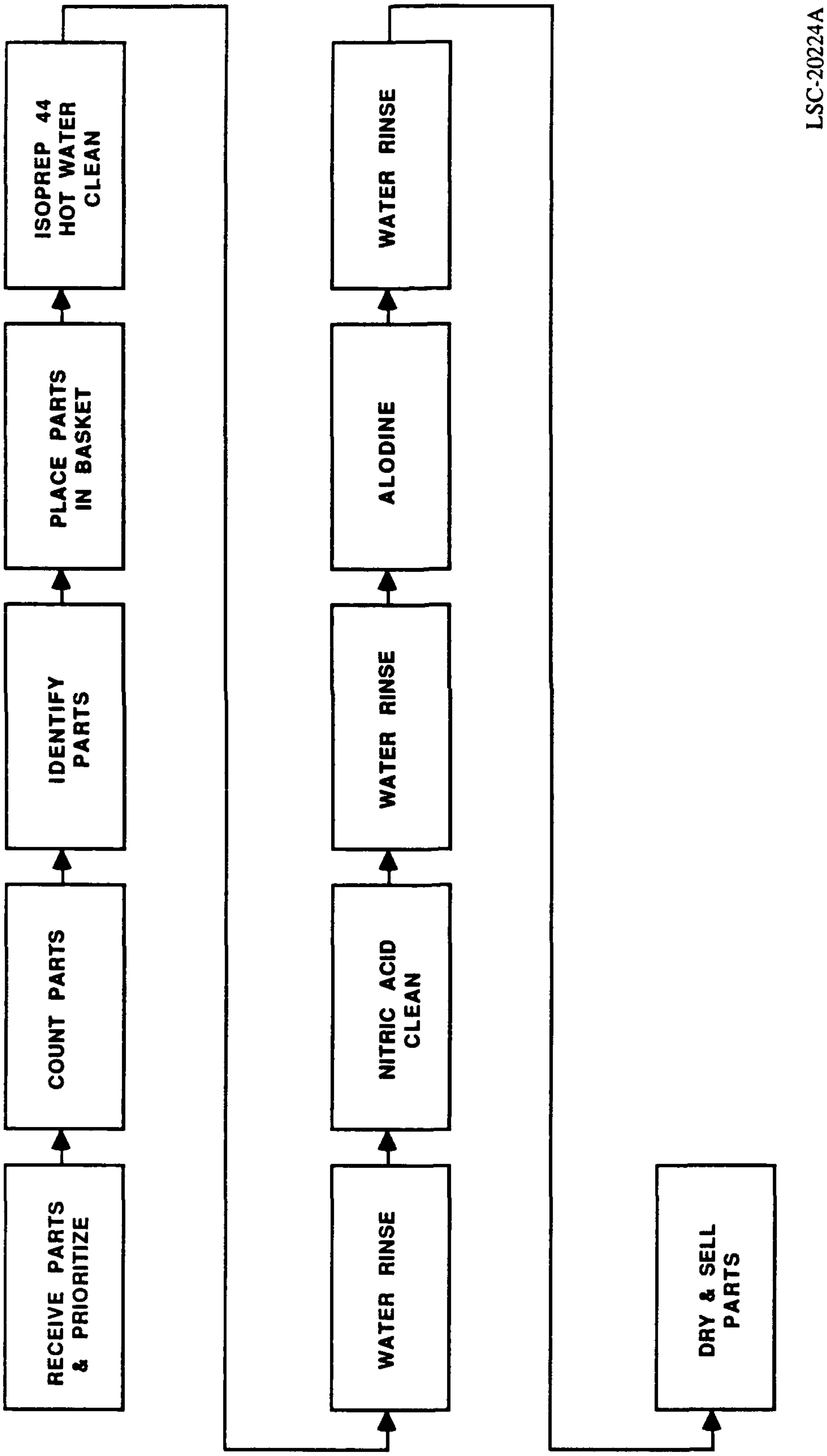


MABPSC TYPICAL SPOT AND SEAM WELD PROCESS FLOW
FIGURE 8.3.1-4

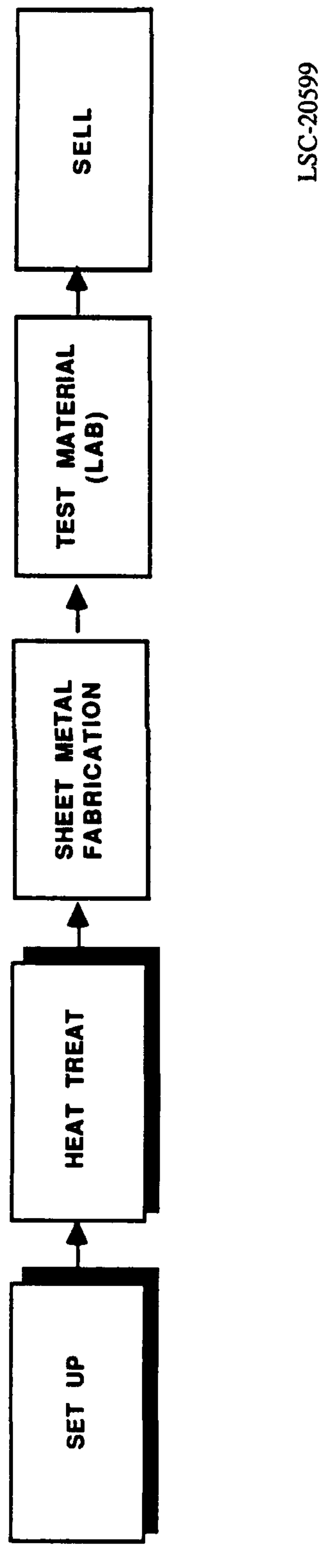
LSC-20227A



MABPSC TYPICAL HELIARC WELD PROCESS FLOW
FIGURE 8.3.1-5



MABPSC TYPICAL ALODINE PROCESS FLOW
FIGURE 8.3.1-6



MABPSC TYPICAL ALODINE PROCESS FLOW
FIGURE 8.3.1-7

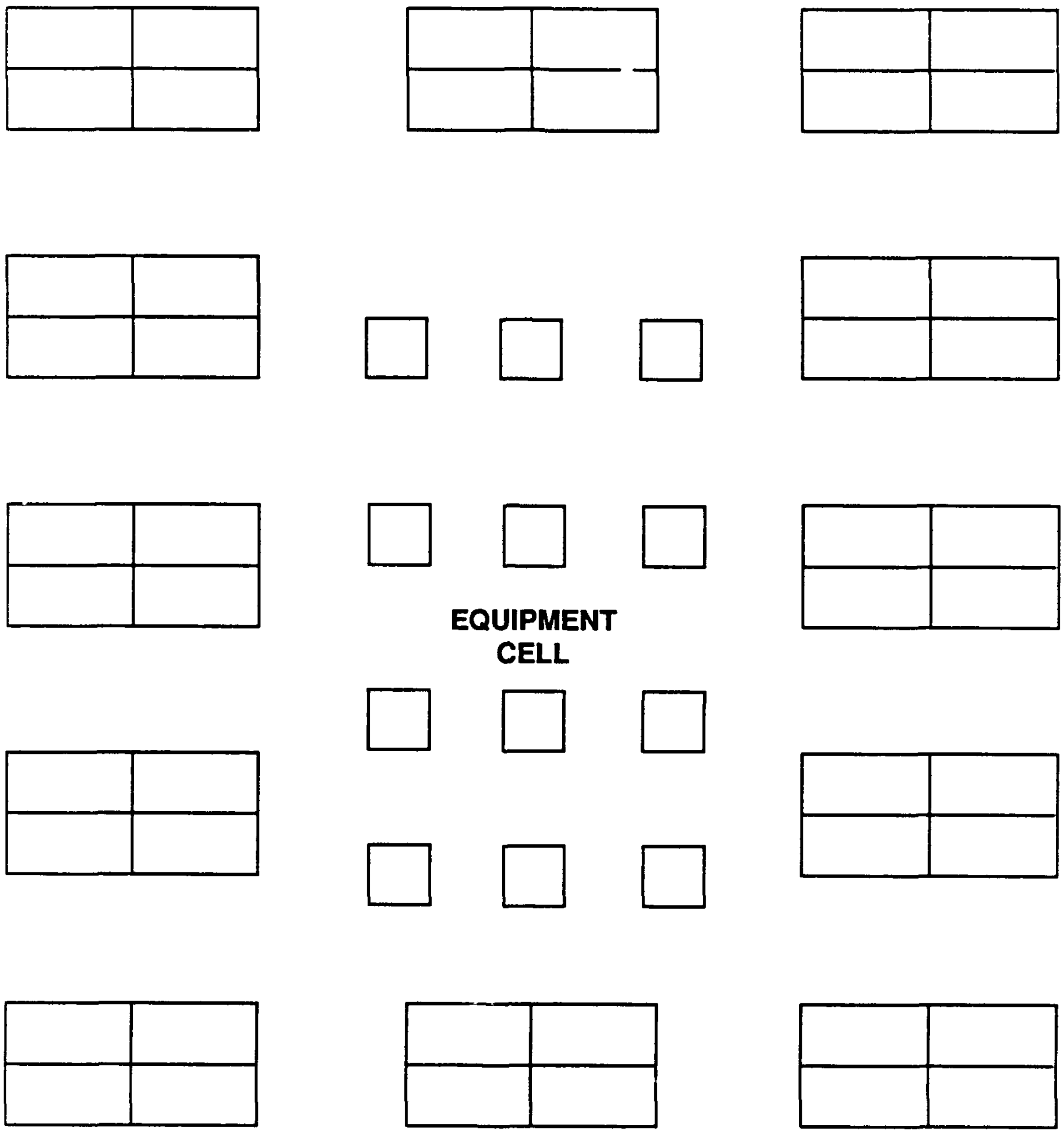
The present layout of equipment and work benches has resulted in a crowded work area. There appears to be some effort put forth in the arrangement of the mechanics workbenches but the lack of adequate floor space prevents the achievement of a satisfactory layout. New equipment is located where floor space is available or where old equipment was removed. This does not lend itself to an efficient placement of equipment for proper work flow. Figure 8.3.1-8 illustrates the MDMSC recommended layout concept. This cellular layout would provide improved product flow and enhanced access to machine tools for preventive maintenance.

The welding and heat treating function is located in an enclosed work area, with free standing walls constructed inside the northern side of Building 375. The area is approximately 102 feet wide by 95 feet long for a total of 9,690 square feet. The facility layout drawing for the welding and heat treating area does not represent the As-Is condition of the equipment layout in the welding and heat treating area. This area is very congested and disorganized. There are at least nine pieces of equipment and work tables which have been relocated by production without notifying the facility engineers for concurrence or blue print updating.

The alodine chemical process line occupies 4,690 square feet. This area is very clean and has adequate floor space. The facility layout drawing, included in the DDB, for the alodine chemical process area is current and represents the As-Is condition.

8.3.1.3 Equipment

The equipment used to fabricate sheet metal parts in MABPSC consists of large, medium, and small tonnage power equipment, manually operated equipment, standard hand tools, special form blocks, and punch and die sets. The equipment used is typical of that found in sheet metal fabrication shops in the private sector. A detailed analysis of the equipment was completed and is provided in paragraph 2.2 (Equipment) of General Information Section 2.0 of the Database Documentation Book.



WORK BENCHES SURROUND
EQUIPMENT CELL

LSC-20600

MABPSC LAYOUT FOR SHEET METAL FABRICATION
FIGURE 8.3.1-8

The equipment consists of 105 pieces of equipment of which seven could not be located by MDMSC. The condition ranges from excellent to broken and is grouped by condition and approximate percentage, as follows:

Condition	Percentage
Excellent	16.3
Very Good	1.0
Good	54.1
Fair	11.2
Poor	6.1
Broken	11.2

This data shows that 11.2% of equipment is out-of-service and is of no use to the RCC at this time. Another 17.3% is in fair to poor condition and, if used, would produce parts of questionable quality.

The equipment ranges in age from one to 50 years old and is grouped by age and approximate percentage as follows:

Age Group	Percentage
1-5	18.8
5-10	9.1
10-15	4.0
15-20	9.9
20-30	28.7
30-40	28.7
40-50	1.0

This data shows that 57.4% of equipment is 20 years old or older. This indicates that Mean Time Between Failures (MTBF) is a significant factor and some of these items should be considered for replacement. The equipment condition and age assessments were made by the RCC personnel assisting MDMSC with the analysis.

During the equipment analysis, it was observed that neither adequate nor proper storage space for tooling is provided at MABPSC. Two areas in particular stand out.

- Storage of punch and die sets for the presses is across the east aisle from MABPSC in an area that is not part of MABPSC. There are numerous (200+) punch and die sets stacked on steel tables with what appears to be little or no organization. Some of the sets are very heavy and should be moved by forklift but there is insufficient space to maneuver, therefore, the die sets have to be moved by hand from the steel table to carts.
- Storage of drop hammer dies is outside, near the drop hammer adjacent to Building 338 Foundry and Pattern Shop. The die sets are large and weigh thousands of pounds, requiring a 10,000 lb. capacity forklift to move. There are (200+) die sets which are stored outside on the ground and stacked on one another. If the desired die set is on the bottom of a stack, time is spent moving and restacking to get the die set required.

Recommended solutions to above-described problems are discussed in paragraph 8.3.6, Other Observations.

The equipment in the welding and heat treating area of MABPSC consists mainly of arc welding machines, heliarc welding machines, seam welding machines, cutting torches, drill presses, saws, grinders, heat treating ovens, a water quenching tank, work benches, a freezer, an overhead monorail crane, and transportation carts. The arc and heliarc welding machines are approximately four years old, and are in good working condition. The five spot welding machines are about 20 years old. Two of the spot welding machines are not in working condition. The main problem with repair of this old equipment is the time and experience it takes to repair it and to obtain replacement parts. The two seam welding machines are in good working condition. Two of the seven heat treating ovens are not in working condition. The large Lindberg oven has been out of order for over six months. One of the small Lucifer ovens has not been used for the last 12 months because of erratic temperature

fluctuations. The only freezer used by the heat treating function has been unable to maintain the proper temperature to keep the aluminum in the quenched (soft) workable condition. A weekly breakdown of this freezer is common. The rest of the equipment in the welding and heat treating area is in satisfactory working condition.

The equipment in the alodine chemical process line consists of one overhead monorail crane, four workbenches, and five alodine chemical processing tanks. The five tanks are: one Isoprep 44, two water rinse, one nitric acid, and one alodine. Four of the tanks are in satisfactory condition. One of the two water rinse tanks has been sitting idle for over one year (since installation). The one used must be maintained in good working condition, because of multiple use during the alodine chemical process.

8.3.1.4 Personnel

PSC, sheet metal fabrication section employs an average of 112 sheet metal mechanics. Although these mechanics are divided into five wage grades, there is a great deal of interchangeability among them. As shown below, 73% of the work force has three or more years of experience. This is consistent with experience levels in many commercial shops.

Skill Level	Job Code	Quantity	Avg. Yrs. of Experience
WG11	3806	9	15 - 25
WG10	3806	44	10 - 20
WG08	3806	18	3 - 10
WG05	3806	30	0.- 3
WG10	3869	11	5 - 25

A brief description of each job code/skill code is found in the DDB, section 2.3.

The variability of the workload can increase or decrease the manpower requirements up to 25% within a quarter. These swings in requirements have a significant effect on personnel utilization rates. When the workload decreases, production is reluctant to decrease manpower, as it may be needed again very

soon. Manpower that has been loaned out, especially if they have been loaned out of the division, may not be retrieved quickly. New personnel or transferees from other RCCs require many hours of training, usually on the job. As a result, although the UDOS model shows an average manpower utilization of 36% to 91% in MABPSC and 65% to 82% in MABWHT, higher than that found in most other RCCs in the command, queues are frequently formed by manpower shortages during some periods. Workers are frequently idle as well. This is discussed further in paragraph 8.3.2.1. To offset this phenomenon, MABPSC/WHT management has instituted a job rotation/cross-training program. MDMSC was unable to judge the effectiveness of this program.

8.3.1.5 Explanation of Current Success

The success of MABPSC/WHT is largely due to the presence of a large, experienced work force. The processes used are generally very labor-intensive and powered equipment is relatively scarce. The planning and engineering functions which support this RCC appear to be over-taxed, forcing the workers in MABPSC/WHT to develop their own processes and design their own tooling. This situation is common within the command (it has been observed in OC-MATPIM and MATPIA as well as others), but virtually unheard of in private industry. The difficulty in obtaining timely planning/engineering support is a serious process problem and is described in greater depth in paragraph 8.3.3.

The work force's high level of experience and ingenuity is also important in overcoming the lack of modern manufacturing equipment. As described in paragraph 8.3.1.3, the bulk of this RCC's equipment is old and generally very low-tech. As various pieces are frequently broken, the workers must develop alternate processes that "work-around" the inoperative machine or substitute handwork for machine work. This can only work with a very large work force. The condition of the equipment in MABPSC/WHT is discussed further in paragraph 8.3.3 and in the focus studies in 8.3.4 and 8.3.5.

MDMSC has surveyed several large commercial airline and third party maintenance centers. While they all maintain some parts-manufacturing capability, none maintained anything on the scale of this RCC. The requirement

for such a large manufacturing capacity suggests problems in the parts procurement system. MDMSC addresses this in more detail in paragraph 8.3.3.

8.3.2 Statistical System Performance Measure

A joint MDMSC/SA-ALC team met 24 July - 3 August 1989 to validate all Block II and III UDOS 2.0 simulation models, including MABPSC/WHT. This was accomplished by comparing simulated flowtimes and throughputs to MABPSC supervisory estimates. Other areas, such as process flow, resource utilization, and location of queues were examined as well, in accordance with the UDOS 2.0 acceptance test procedure previously delivered. Details of the validation can be found in the validation meeting minutes and in section 8.0 of the DDB.

A common brainstorming session for all Block II and Block III RCCs was conducted at the conclusion of the validation. The ideas collected were reported in Appendix A of the validation minutes. The Taguchi orthogonal array and the experimentation were completed by MDMSC in St. Louis.

The MABPSC sheet metal section experiments are described in paragraph 8.3.2.2, while WHT is covered in paragraph 8.3.2.3.

8.3.2.1 Statistical Analysis of Current Conditions

The current configuration of MABPSC produces an average throughput (number of parts out/number of parts in x 100) of 99% when modeled on UDOS 2.0. Throughput by PCN ranges from the STL-HF-HT (100%) to STL-DH (98%). The primary causes for a throughput less than 100% are the occasional high utilization of the drop hammer, and a shortage of manpower. The new drop hammer, scheduled to be in-service soon, will eliminate the queuing currently caused by this situation.

Equipment utilization is very low with most machines between 1-50%. The highest utilization was the drop hammer at 50%. The low utilization rate does not indicate excess equipment, but is typical in a short-run manufacturing operation with a large number of speciality machines.

Manpower utilization for the skill areas (SF 05, 08, and 10 sheet metal mechanics) ranged from 71% to 91% on the first shift and 49% to 68% on the second shift. Only 15% of the mechanic work force is currently assigned to second shift in PSC and 8% in WHT. These utilization figures do not include time spent on indirect activities (cleanup, ordering parts, etc.), but include average time lost to vacations, sick leave, and training. This high utilization is caused by the use of manual processes, instead of machine, on many efforts.

There are no significant bottlenecks in the MABPSC process flow. Most queues are caused by manpower shortages and appear throughout the process. All part numbers in WHT spend 4% to 87% of their flowtime in queues, while parts in PSC spend 2% to 45%. These figures do not include delays caused by material shortages, awaiting engineering assistance, or administrative delays. Those parts with very large percentages of delay tend to be parts with very short flowtimes, however, so total delays are actually very small.

8.3.2.2 MABPSC Sheet Metal Experimentation

Brainstorming was conducted in one session for all four Block II and Block III RCCs. The bulk of the ideas generated for experimentation would affect the length of time required to perform the operations in these RCCs. These ideas were presented in broad terms and included:

- Age of equipment - if newer, more effective equipment were available, operation times could be shortened.
- Quality of equipment - if the equipment purchased were of a better quality, operation times could be shortened.
- Newer and better hand tools - the same arguments for equipment held for hand tools
- Better selection of personnel - if new hires were more trainable for their positions, the length of time it took to perform operations would be shortened. It was felt that the quality of incoming personnel was not what it should be. The representative from the heat treat and welding area felt that this reason would not apply to their area.

As only rough estimates of the effect of each idea were available, MDMSC decided to test the overall effects of reduced operation times on MABPSC. A set of experiments was run with all of the operations reduced by a specified percentage. The purpose of these of experiments was to study the effects of these changes on the flowtimes for the RCC.

The experimentation was developed to compare the flowtimes from six runs. The descriptions of the runs are:

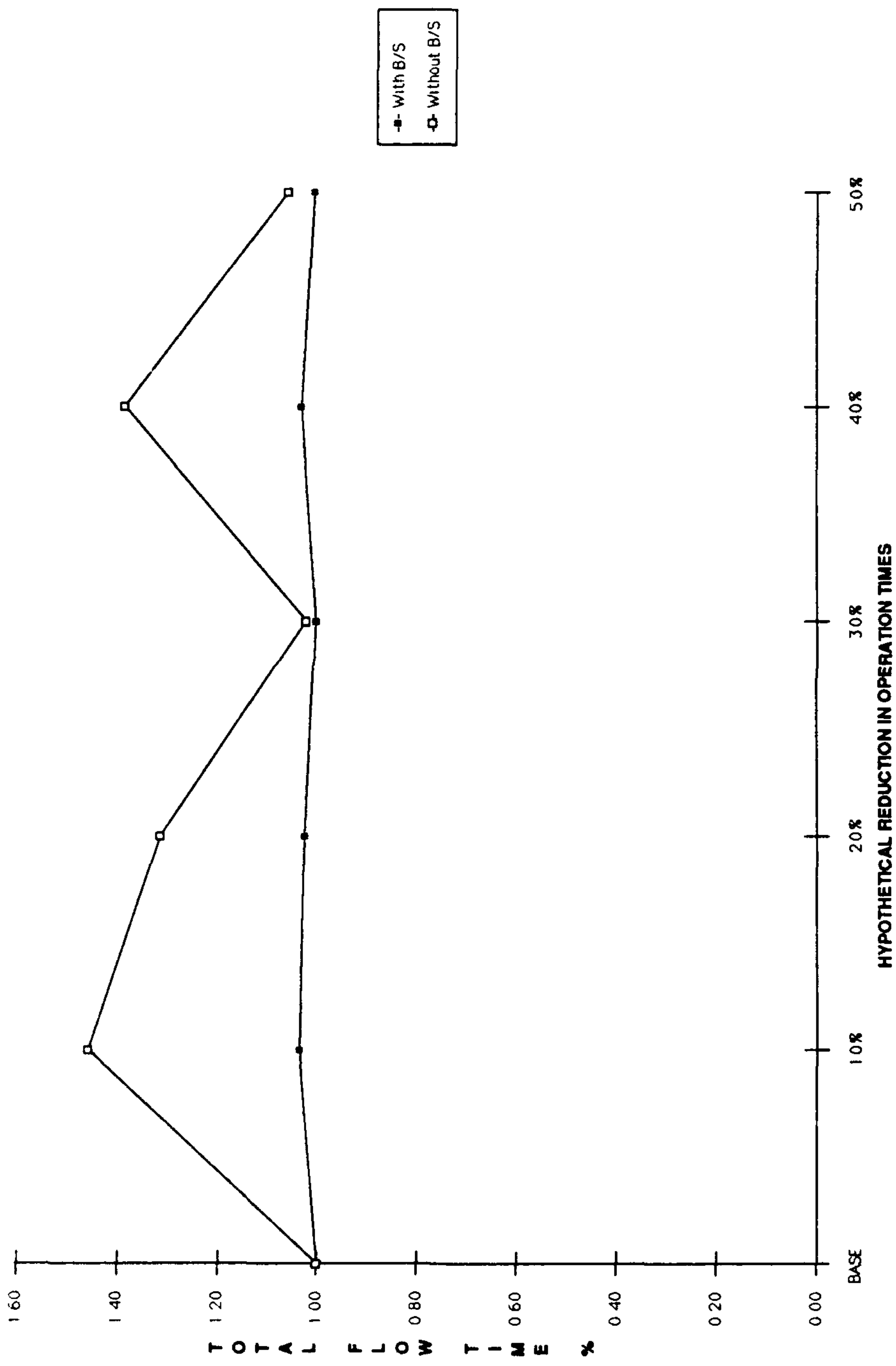
- The Baseline data.
- The Baseline with all processing operations reduced by 10%.
- The Baseline with all processing operations reduced by 20%.
- The Baseline with all processing operations reduced by 30%.
- The Baseline with all processing operations reduced by 40%.
- The Baseline with all processing operations reduced by 50%.

Tables showing a summary of the flowtimes by item and average back shop hours are shown in the Experimentation Section of the MABPSC DDB. A total flowtime for the RCC was calculated and a percentage reduction from the baseline was calculated for each run. A similar calculation was made with the back shop times excluded from the flowtimes.

Figure 8.3.2.2-1 shows results when the back shop times overwhelmingly dominate the flowtimes. The reduction in operation times has a negligible effect on the total flowtimes and the variation around the as-is flowtimes is due to random fluctuations of simulation. Concentrating on the time spent in back shops produces the best results.

8.3.2.3 WHT Experimentation

The WHT experimentation was designed using a Taguchi orthogonal array. The array selected for experimentation was an L_4 with three factors at two levels each. This array is shown in Table 8.3.2.3-1. Four experimental model runs for the heat treat and welding unit were performed by MDMSC in this experiment. The simulated average flowtimes and throughputs were collected and analyzed for each of the nine PCNs characterized in MABPSC. The detailed analysis



% of Base Flow Times for Sheet Metal Manufacturing Unit

MABPSC EXPERIMENTATION WITH REDUCED OPERATION TIMES
FIGURE 8.3.2.2-1

LSC-20588

MABWHT L_4 TAGUCHI ORTHOGONAL ARRAY
TABLE 8.3.2.3-1

FACTORS

RUN #	WORKLOAD	OPERATION TIMES	SET UP TIME
1	AS-IS	AS-IS	AS-IS
2	AS-IS	REDUCED 20%	REDUCED 20%
3	INCREASED 30%	REDUCED 20%	REDUCED 20%
4	INCREASED 30%	REDUCED 20%	AS-IS

sheets are included in section 10.0 of the DDB for MABPSC. An overview of the throughput results is summarized in Table 8.3.2.3-2. The conclusions reached from analysis of the experiments are as follows:

- Factor A (30% increase in Workload Levels) produced no significant effects on RCC throughput or flowtime, except for PCN X8137687. Throughput for this PCN dropped 17% while the average flowtime increased 86%. This sharp effect is caused by several operations in the processing of this PCN which require several workers simultaneously. Under the increased workload, it was more difficult for the UDOS 2.0 model to find sufficient available workers to complete these operations. In MDMSC experience, the UDOS 2.0 model is far more sensitive to this situation than actual operations under human supervision. MDMSC does not feel that this effect is a significant indicator of a problem in the RCC's operation.
- Factor B (20% reduction in Operation Times) produced no significant effects on RCC throughput except for PCN X8137687. Flowtimes decreased from 0-14% for all PCNs except X8137687 and X8950671. This exception is caused by an interaction described below. The change in X8950671 is the same as for X8137687 though smaller because it requires only three workers versus four for X8137687. Based on the explanation provided under Factor A, MDMSC does not feel that these effects are significant indicators of a problem in the RCC's operation. A more detailed analysis of this factor is described in paragraph 8.3.2.2.
- Factor C (Reduced Set-up Times) produced no significant effects on throughput or flowtime for any PCN is this RCC. While PCN X8137687 appeared to show a significant response (Flowtime up 70%, Throughput down 22%), MDMSC feels that this effect is actually caused by a strong interaction between Factors A and B. The L_4 array used in this experiment assigns the effects of interactions between Columns 1 and 2 (Factors A and B here) to Column 3 (Factor C). This aspect of the array's design is often used to specifically model interactions, where their quantification is important.

"MABWHT" L_4 TAGUCHI ORTHOGONAL ARRAY THROUGHPUT EXPERIMENTAL RESULTS - FY 88

TABLE 8.3.2.3-2

EXP #	A WORK LOAD	B OPERATION TIMES	C INDUCTIONS	NORMAL WORKLOAD		
				AVG	BEST	WORST
1	AS-IS	AS-IS	AS-IS	99.0 %	B3510703537 / 101%	X8137687 / 95%
2	AS-IS	- 20 %	- 50 %	99.9 %	X8950671 / 102%	X8137687 / 98%
3	+ 30 %	AS-IS	- 50 %	97.1 %	BT4H04103171A / 101%	X8137687 / 58%
4	+ 30 %	- 20 %	AS-IS	100.3 %	X8137687 / 101%	ALL OTHERS / 100%

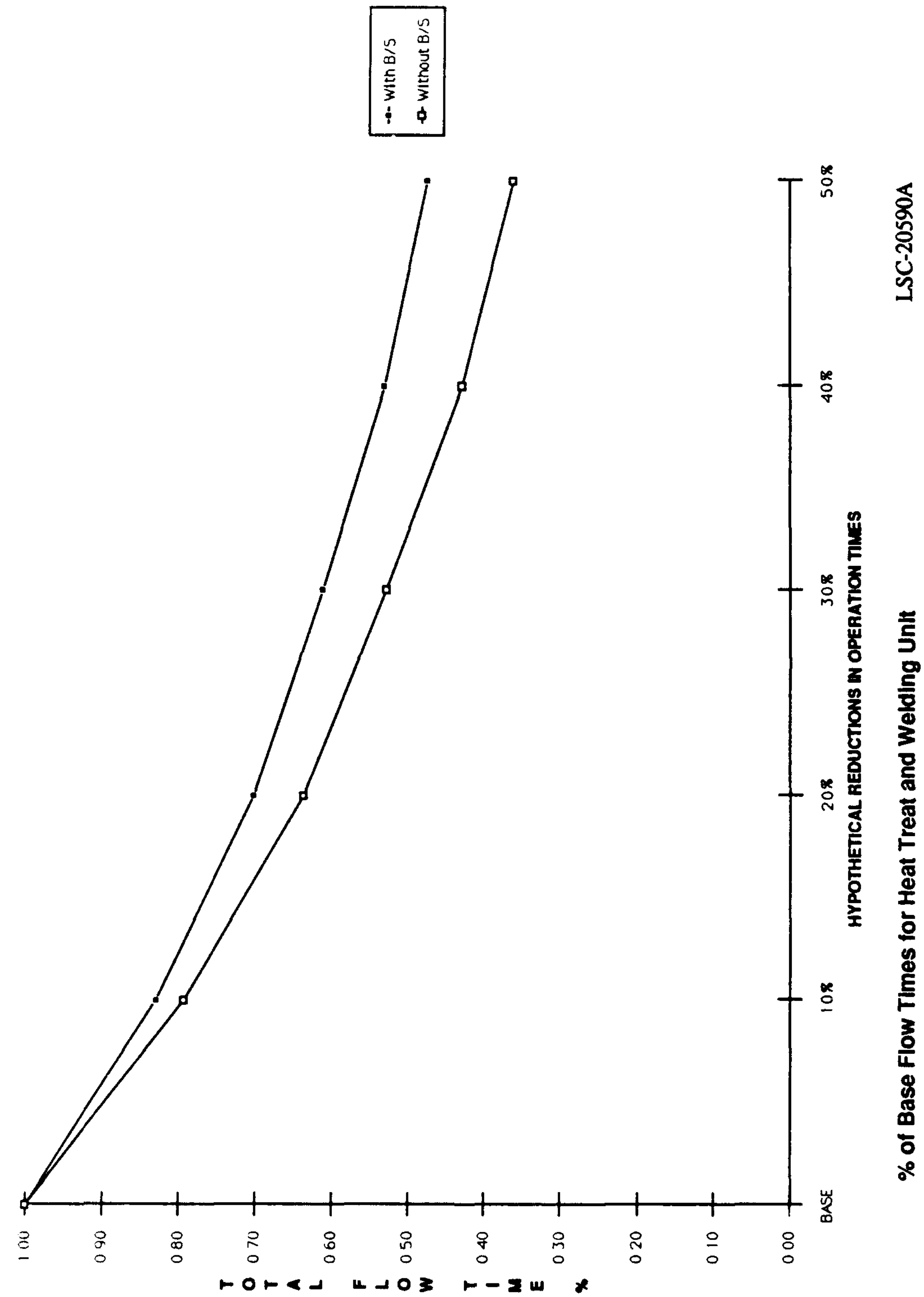
LSC-20604

In this case, while no interactions were specifically modeled, the generally flat response of Factor C elsewhere, coupled with X8137687's pronounced shift against the expected trend (a reduction in set-up time caused a huge increase in flowtime) causes MDMSC to attribute this move to an interaction. X8137687 is very sensitive to changes in operation times under increased workload but very insensitive under normal workload. This is caused by the manpower situation described under Factor A and is not considered a significant indicator of a problem in the RCC's operation.

A second set of experiments, identical to those performed in MABPSC, was performed for WHT. Operation times were reduced by the same increments as used in paragraph 8.3.2.2. Figure 8.3.2.3-1 for Welding and Heat Treat shows a greater percentage reduction in total flowtimes than that in operation times. This is due primarily to those items that require several people to perform an operation. This is the same situation as that observed in MABPSB. Further details can be found in paragraph 8.2.2.2. As in MABPSB, MABWHT is an excellent candidate of additional material handling assistance. This is described in more detail in paragraph 8.3.2.4 and the Quick Fix Plan.

8.3.2.4 Additional Experimentation

Other experimentation was conducted to support focus study recommendations. Three experiments were conducted to study their effect on manpower requirements. The reductions in processing times were conservatively estimated so that that the results would show the minimum expected savings. The statistic of interest in these experiments is the number of man hours required by the RCC over a period of one year. The results are measured by the number of manhours saved. The results are shown in Table 8.3.2.4-1. Since the FY 90 workload could vary from the workload level under study, savings are shown for varying workloads from the studied year. No interactions between the runs were observed, as the experiments were conducted independently of one another. Savings resulting from implementing the ideas behind the experiments would be cumulative.



MABPSC EXPERIMENTATION WITH REDUCED OPERATION TIMES
FIGURE 8.3.2.3-1

SINGLE RUN EXPERIMENTATION RESULTS
TABLE 8.3.2.4-1

WORKLOAD FACTOR	HOURS REQUIRED	HOURS SAVED		
		EXP 1	EXP 2	EXP 3
80%	88502	903	1918	9594
100%	110628	1129	3527	15520
120%	132754	1355	2878	14392
140%	154879	1581	3357	16790
160%	1[illegible]05	1806	3837	19189
180%	199130	2032	4316	21587

NOTE: TOTAL MANHOURS AVAILABLE PER YEAR: 151,424

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The experiments are described as follows:

Experiment 1 - The purpose of the experiment was to study manpower savings resulting from assigning one person to pull and cut (shear) sheet stock to approximate size (a blank). The savings would result from having one person perform the work instead of many different people. In addition, savings would result from sorting work orders so that the same material could be cut at the same time. The amount of time taken to obtain the material was reduced from an average time of .5 hours to an average time of .2 hours, and the average shear time was reduced from .01 hours per item to .007 hours per item.

Experiment 2 - The purpose of the experiment was to study manpower savings resulting from reducing the scribe and sawing operations by increased use of routers, nibblers and blanking using steel rule dies and other methods. Scribe and sawing operations were reduced by 50%. Deburring operations were changed so that they occurred 50% of the time for .01 hours per item. A route or blanking operation was added to substitute for the reduction in sawing and scribing and a new piece of equipment was added to represent the new method. The usage of the machine indicated that one would be sufficient over the range of workloads examined.

Experiment 3 - The purpose of this experiment was to study manpower savings resulting from replacing hand forming with press forming using proper press and form blocks. A press forming operation of .1 hour per item was added. Hand forming operations were reduced by 50% to reflect replacement with press forming equipment. Two press forming machines were added in order to accommodate the studied workload. The two pieces of equipment should be enough to accommodate a varied workload, including surge conditions.

Experiments 1 - 3 all indicated potential cost benefits for the RCC. These results are used to support recommended focus studies and one quick fix. Further details are provided in paragraphs 8.3.4 through 8.3.6.

8.3.2.5 Surge Analysis

An analysis was made of the effect of varying the workload from the studied year's workload to determine the effect on the manpower requirements. The workload was varied by a certain percentage for all of the items characterized. It is assumed that any percentage change in workload would be the same for all of the items. Typically, a surge workload is 160% of the normal workload. The results of the analysis are shown in Table 8.3.2.5-1.

The conclusions drawn from the MDMSC analysis of this experiment are as follows:

- Sheet Metal Manufacturing can meet an increase in workload of 20% without straining the manpower resources as they are currently scheduled (taking into account that 80% of the workload was characterized). If the manpower were divided into two 12-hour shifts, seven days a week, representing a war time environment, then an increase of over 100% in workload can be accommodated, though the drop hammer would be heavily utilized. As an additional drop hammer is projected to be on-line within the next few months, it is not considered a problem. The brakes could become a bottle-neck, not because of over-utilization, but because of failure problems. During a surge scenario, preventative maintenance on the brakes would become important in order to prevent them from becoming a bottleneck. While manpower can be substituted for the brakes if needed, the added strain during a surge scenario is not recommended. Flowtimes would actually be reduced during the surge scenario because of manpower availability 24 hours a day.
- The heat treat and welding area can meet an increase of 40% in workload without straining the manpower resources as they are currently scheduled. If the current manpower were divided into two 12-hour shifts, seven days a week, representing a war time environment, then an increase of over 100% in workload could be accommodated. Equipment would not be a limiting factor. Flowtimes would actually be reduced during the surge scenario because of manpower availability 24 hours a day.

FY 90 AND SURGE ANALYSIS
TABLE 8.3.2.5-1

SHEET METAL MANUFACTURING UNIT	
HOURS AVAILABLE:	
MANPOWER AS-IS	MANPOWER SURGE
151,424	317,990
WORKLOAD FACTOR	HOURS REQUIRED
80%	88502
100%	110628
120%	132754
140%	154879
160%	177005
180%	199130

HEAT TREAT AND WELDING UNIT	
HOURS AVAILABLE:	
MANPOWER AS-IS	MANPOWER SURGE
17,790	37,359
WORKLOAD FACTOR	HOURS REQUIRED
80%	7770
100%	9713
120%	11656
140%	13598
160%	15541
180%	17483

LSC-20592A

8.3.2.6 Conclusions and Recommendations

MDMSC concludes that MABPSC/WHT has sufficient resources to meet current and projected workloads, including wartime surge. MDMSC offers the following recommendations to MABPSC management, based on the results of experimentation:

- MABPSC management should consider shift work to gain improvements in flowtime in order to better service other RCCs, (especially in the heat treat and welding area).
- While reducing the time to perform operations would yield improvements in flowtimes, these improvements would not be dramatic. MABPSC Management should consider shift work before investing in improvements in the current operations to reduce flowtime.
- MABPSC management should consider the focus study recommendations in this report as sources of potential cost savings/cost avoidance, quality improvements, and reduced flowtimes.

8.3.3 Description of Process Problems

The processes in MABPSC/WHT are generally labor-intensive and performed using old, inefficient equipment. Sheet metal is frequently formed by hand, using lead bars, rawhide hammers, or manually-operated pieces of equipment. The problem is not only the excess use of the mechanic's time and energy, but also the parts produced are of lower quality because of their variability.

Some equipment and machines essential to forming parts are not operational. In some cases, the required tooling is not available or is not designed and built to yield results desired by this RCC.

The Aircraft Division (MAB) does not have a tool and die making operation. Therefore, MABPSC must depend on the tooling fabrication capabilities in MAT or seek outside contractor support. The tooling fabrication shoo in MAT gives higher priority to their own tooling needs ahead of MABPSC's. This, plus the extra paperwork required to cross division lines, increases lead time to obtain the necessary tooling. To work around this problem, the layout operators in MATPSC make what tools they can.

This willingness and ability to "work-around" speaks well for the operators, but hides the fact that they are not receiving adequate engineering or tooling support. In many commercial operations (MDMSC and American Airlines for example) tool designers and process engineers are stationed on the shop floor, under the supervision of the shop chief. MDMSC recommends this for MABPSC.

A similar situation exists for the planning and facilities layout support functions. The work force in MABPSC routinely develop and plan their own production processes and develop their own layouts. This results in a confused layout, as described in paragraph 8.3.1.2, and inefficient processes, per paragraph 8.3.1.1. While paragraphs 8.3.4 and 8.3.5 address solutions to two of the most obvious process problems, the entire RCC is rife with antique processes. These arduous, labor-intensive processes, coupled with an ineffective shift schedule mean long lead times for parts, and a perception on the part of MABPSC customers that the RCC is slow and unresponsive. Without process characterizing the aircraft lines MABPSC supports, it is impossible for MDMSC to quantify the cost of this problem. In MDMSC's experience, however, such "unresponsiveness" normally causes customers to over order, building up stock piles of buffer inventory to protect their own schedule. This relieves the schedule pressure on MABPSC, but greatly increases their workload and boosts the cost of overhauling aircraft.

The sheer size of this RCC indicates a problem in itself. The manufacturing capacity in MAB greatly exceeds that maintained by commercial aircraft overhaul facilities. AAR Corporation of Oklahoma, for example, has only four employees dedicated to manufacturing. AAR performs depot overhaul services for a variety of narrow-body jetliners, many of which are as old as the B-52s repaired at SA-ALC. While direct comparisons are difficult, it is quite apparent that these two maintenance facilities have very different attitudes toward manufacturing.

Manufacturing aircraft parts is an involved process for a civilian repair facility. The part must be manufacturing using only current drawings and FAA-approved processes provided by the original manufacturer. The part is manufactured on a one-time-only basis and detailed documentation must be provided to an FAA inspector. In the Air Force, which is not governed by civilian Federal Aviation Regulations (FARs), parts can be routinely manufactured, using processes developed by journeyman sheet metal mechanics, and no documentation is required. As a result, SA-ALC finds itself with an ever-growing manufacturing business.

While having a huge manufacturing capability in-house is convenient, it is also enormously expensive. Given the large quantity of short-run manufacturing businesses in the United States, and the ready availability of cheap, reliable overnight delivery services, MDMSC questions the need for so much manufacturing capacity. Rather than spend large sums of money bringing MABPSC up to current commercial standards, SA-ALC should consider a more aggressive program of subcontracting. MDMSC recommends that a study of this possibility be included in any PDM line characterizations performed at SA-ALC in the future.

8.3.4 Recommended Focus Study: Improve Product Quality and Cost by Machine Forming of Parts

The objective of this focus study is to design an improved sheet metal forming process in MABPSC which would improve the quality of the product while drastically reducing the volume of manual labor.

The goals of the design process would be to:

- Minimize the variability of the sheet metal processes used in MABPSC.
- Drastically reduce the lead time required to manufacture a part in MABPSC.
- Significantly reduce the cost of manufacturing in MABPSC.

A focus study criteria checklist is provided in Table 8.3.4-1. A list of proposed MDMSC activities under this focus study is detailed in Table 8.3.4-2. The proposed deliverable items under this focus study are:

- An equipment maintenance and replacement plan and schedule, including an assessment of current LIFT plans.
- A tooling plan, identifying who is responsible for design, manufacture, and storage of tooling.
- A recommended planning guideline to minimize the variability introduced by the process planning function.
- A training plan describing all training requirements and recommending responsibility.
- A recommended flow plan/floor layout to support the new RCC design.
- A UDOS 2.0 (or later) model of the MDMSC recommended RCC design.
- A report describing the recommended personnel mix and work schedule, with supporting documentation.
- Four monthly status reports, describing activities/progress to date.
- A final CSR, describing the results of the focus study and summarizing MDMSC recommendations for further action.

8.3.4.1 Rationale Leading to Change

The sheet metal forming processes in MABPSC are based on antiquated machines and labor-intensive hard work. This results in long lead times in obtaining manufactured parts, poor quality (defined as high variability) in the products, and the requirement for an enormous work force. This situation dramatically boosts the costs of sheet metal manufacturing at SA-ALC. Customers, faced with long lead times, normally over-order and then stockpile parts, increasing inventory costs. The heavy dependence on manual labor requires personnel costs that any commercial operation would call excessive. Finally, the high degree of process variability generates a needlessly high level of rework.

This situation is exacerbated by the difficulty MABPSC workers experience in obtaining tooling, planning, and engineering support. These functions, apparently over-burdened, are unable to give the RCC timely support. As a

MABPSC FOCUS STUDY CRITERIA CHECKLIST

TABLE 8.3.4-1 (SHEET 1 OF 2)

AREA OF ANALYSIS	ACTIVITY (WHAT & HOW)
Process/Material Flow	Outline sequence of process steps with proposed process. Identify critical points in process. Identify critical points in process flow.
Equipment/Work Place Layout	Develop plans for equipment and layout under new design.
Facility Requirements	Analyze requirements for proposed new layout.
Labor Standards	Provide information on new processes to MAB planners to update standards.
Manpower	Provide assessment of required manpower under new RCC design.
Task Assignments	Assess and define functions and tasks with proposed technology changes.
Material Requirements	Determine tooling support requirements. Propose a plan for meeting requirements.
Scrap Rates	Scrap rates are not currently tracked. No data available.

LSC-20606A

MABPSC FOCUS STUDY CRITERIA CHECKLIST

TABLE 8.3.4-1 (SHEET 2 OF 2)

AREA OF ANALYSIS	ACTIVITY (WHAT & HOW)
Material Handling & Storage Methods	Develop new material handling/storage plan.
Inspection Techniques	Examine current methods; propose specific changes, if required, for machine forming.
Equipment/Tools/Fixtures	Define system requirements; assess utility of new equipment. Develop plans for procurement, modification, fabrication.
Process Delays	Provide critical path analysis of proposed system.
Part Identification	No impact.
Quality	Assess product quality under proposed plan.
Personnel Safety	Identify safety concerns with new processes.
Environmental Assessments	Not directly studied.

LSC-20606A

PROJECTED MDMSC ACTIVITIES

TABLE 8.3.4-2

STEP	ACTIVITY
1	Perform process planning study. Expand current process family groupings and identify the algorithms for selecting the process to be used. Provide the results to SA-ALC in the form of a deliverable planning guideline.
2	Identify the equipment which should be used to perform each process, based on quality requirements and projected workload.
3	Develop a plan for the acquisition/maintenance/replacement of equipment identified in step 2. Provide this plan to SA-ALC as a contract deliverable.
4	Perform a product flow analysis and develop a new flow plan/layout for MABPSC. Provide this to SA-ALC as a contract deliverable.
5	Assess the tooling requirements of the new equipment and develop a plan to meet these requirements. Submit the plan to SA-ALC as a deliverable.
6	Model the proposed RCC design using the UDOS 2.0 (or later) simulation model. Use this model to determine a recommended personnel mix and work schedule. Provide this data to SA-ALC as contract deliverables.
7	Identify the training required to support the recommended personnel structure. Provide a training plan to SA-ALC as a deliverable.
8	Provide a detailed CSR to SA-ALC as the final contract deliverable.

result, untrained sheet metal mechanics in MABPSC are routinely designing their own tooling and developing their own manufacturing processes. This situation produces predictable results and is virtually unheard of in commercial industry.

8.3.4.2 Potential Cost Benefits

An annual recurring cost savings of $428,197 occurs from the implementation of the recommended improvements as shown in Table 8.3.4.2-1.

The investment cost of the recommendations is estimated at $375,000. This cost includes the focus study effort and the implementation cost.

The Cost Benefit Analysis (CBA) shows an Internal Rate of Return (IRR) of 113% and a savings of $1,230,688 in terms of Net Present Value (NPV) using constant FY 89 dollars, see Figure 8.3.4.2-1. The CBA is in compliance with Air Force Regulation AFR173-15, cost analysis procedures, dated 4 March 1988 and rates per AFLC 78-3.

The CBA covers the time frame starting with the focus study through five years after the completion of implementation. The recurring cost savings was assumed to start at the end of implementation.

The NPV takes into account the time value of money and is calculated by discounting a cash flow. The focus study cost, implementation cost, and the recurring savings were spread by fiscal year quarters and discounted back to the first quarter by using a mid-quarter discounting factor equivalent to an annual discount factor of 10%. Basically, this means a dollar that is earned in FY 90 is worth $.91 in FY 89 terms ($1.00/1.1), due to the ability to borrow or lend at a positive interest rate.

A sensitivity analysis was performed in which the investment cost varied between 50% and 200% of the estimated costs, see Figure 8.3.4.2-2.

SUMMARY OF INVESTMENT COST AND ANNUAL SAVINGS (CONSTANT FY89 DOLLARS)
TABLE 8.3.4.2-1 (SHEET 1 OF 2)

	CURRENT ANNUAL COSTS	PROPOSED CHANGE INVESTMENT COSTS	PROPOSED CHANGE ANNUAL COSTS
NONRECURRING COSTS (1)			
FOCUS STUDY	$0	$210,000 (2)	$0
FACILITIES			
LAND	$0	$0	$0
BUILDINGS	$0	$0	$0
SUPPORT EQUIPMENT			
DEVELOPMENT	$0	$0	$0
ACQUISITION	$0	$150,000 (3)	$0
INSTALL & CHECKOUT	$0	$15,000 (4)	$0
LOGISTICS SUPPORT			
INITIAL SPARES	$0	$0	$0
INITIAL TRAINING (DEV & PRESENTATION)	$0	$0	$0
TECHNICAL DATA	$0	$0	$0
TOTAL NONRECURRING COST	$0	$375,000	$0
RECURRING COSTS (1)			
TOUCH LABOR	$3,052,227 (5)	$0	$2,624,030 (6)
SUPPORT EQUIP MAINT	$0	$0	$0
SPARES AND SPARES MGMT	$0	$0	$0
TECHNICAL DATA	$0	$0	$0
MOD KITS	$0	$0	$0
CONFIGURATION DATA MGMT	$0	$0	$0
UTILITIES	$0	$0	$0
TOTAL RECURRING COSTS	$3,052,227	$0	$2,624,030
TOTAL COSTS	$3,052,227	$375,000	$2,624,030
ANNUAL COST SAVINGS	$428,197		

NUMBER OF MONTHS FOR FOCUS STUDY 5

NUMBER OF MONTHS TO IMPLEMENT CHANGES 6

SUMMARY OF INVESTMENT COST AND ANNUAL SAVINGS (CONSTANT FY89 DOLLARS)
TABLE 8.3.4.2-1 (SHEET 2 OF 2)

NOTES:

(1) ONLY ITEMS THAT ARE SIGNIFICANTLY AFFECTED BY THE PROPOSED CHANGE HAVE BEEN ESTIMATED

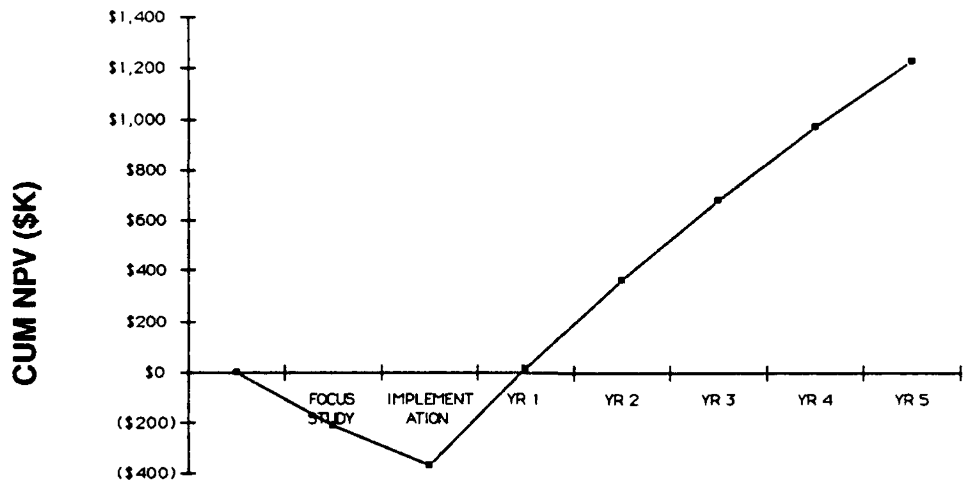
(2) ENGINEERING ESTIMATE FOR USE IN ENGINEERING TRADE STUDIES ONLY, DOES NOT REPRESENT FIRM PRICING

(3) ENGINEERING ESTIMATE (ROM) OF ACQUISITION COST FOR TOOLS AND EQUIPMENT.

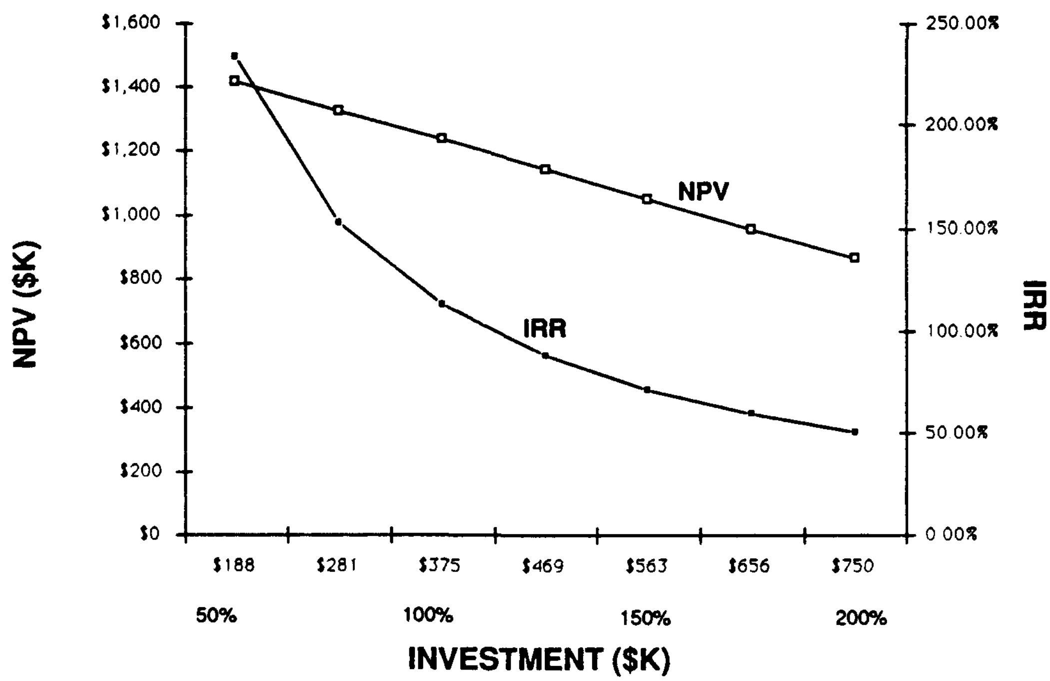
(4) INSTALLATION COST IS ESTIMATED AT 10 PERCENT OF EQUIPMENT COST.

(5) CURRENT TOUCH LABOR FROM MODEL EXPERIMENTATION RUNS = 110,628 HOURS X $27.59/HOUR = $3,052,227.

(6) PROPOSED TOUCH LABOR FROM MODEL EXPERIMENTATION RUNS = 95,108 HOURS X $27.59/HOUR = $2,624,030.



CUM NPV IN CONSTANT FY89 DOLLARS
FIGURE 8.3.4.2-1



CBA SENSITIVITY ANALYSIS
FIGURE 8.3.4.2-2

8.3.4.3 Risk Assessment of Achieving Goals

The proposed machine forming technologies are in common use throughout private industry, as well as, other areas in AFLC. OC-MATPIA for example, currently makes extensive (and effective) use of various machine presses for sheet metal forming in short-run manufacturing situations. MDMSC feels there is no technological risk of not achieving project goals.

Given the widespread use of machine pressing, and MDMSC's familiarity with the technology, MDMSC has high confidence in the reliability of the manpower and flow time savings estimates included in this focus study. A test of the effects of these changes, simulated on the UDOS 2.0 Model confirmed MDMSC's projections of results (see experiment 3, paragraph 8.1.2.2). MDMSC feels that the risk of the recommended changes not producing acceptable savings is very low.

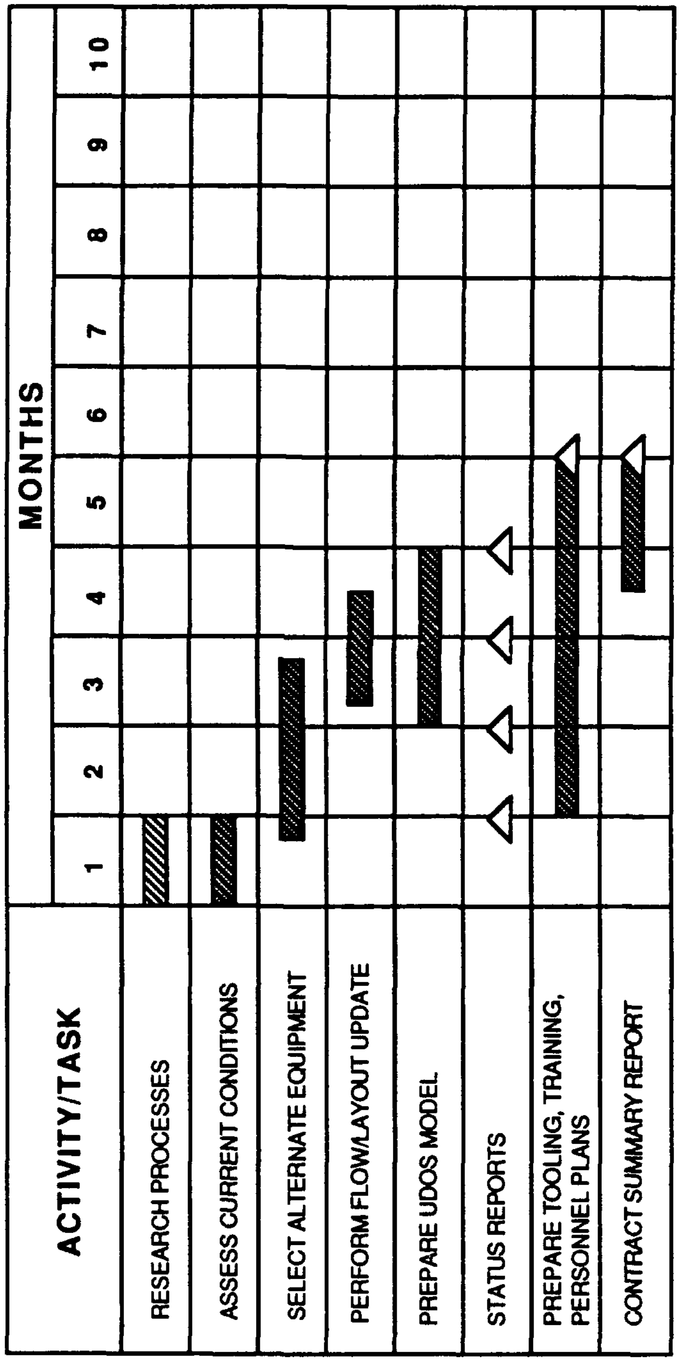
As the type of capital equipment studied for procurement under this focus study is in common use both in and outside of AFLC, its cost to the U.S. government can be projected very reliably. This causes MDMSC to conclude that the risk of actual implementation costs exceeding the MDMSC estimates to be very low.

Given the conventional nature of this focus study and the technology it proposes to study, MDMSC concludes that the risk of not achieving the study's goals is very slight.

8.3.4.4 Duration and Level of Effort

The proposed schedule is presented in Figure 8.3.4.4-1. The total duration of the study will be five months from date of contract turn-on. The level of effort will be:

One MDMSC tooling specialist 1/2 time -	385 manhours
Two MDMSC industrial/manufacturing engineers full time -	1540 manhours
One MDMSC simulation expert 1/2 time -	385 manhours



LSC-20580A

PROPOSED FOCUS STUDY SCHEDULE

FIGURE 8.3.4.4-1

It is estimated that $375,000 is required to successfully implement this recommendation. The number is an engineering Rough Order of Magnitude (ROM) estimate for engineering trade studies only; it does not represent firm pricing.

8.3.5 Recommended Focus Study: Provide an Efficient Process for Cutting Parts to Outline

The objective of this focus study is to design an improved sheet metal cutting process in MABPSC which would improve the quality of the product while drastically reducing the volume of manual labor.

The goals of the design process would be to:

- Minimize the variability of the sheet metal processes used in MABPSC.
- Drastically reduce the lead time required to manufacture a part in MABPSC.
- Significantly reduce the cost of manufacturing in MABPSC.

A focus study criteria checklist is provided in Table 8.3.5-1. A list of proposed MDMSC activities under this focus study is detailed in Table 8.3.5-2. The proposed deliverable items under this focus study are:

- An equipment maintenance and replacement plan and schedule, including an assessment of current LIFT plans.
- A tooling plan, identifying who is responsible for design, manufacture, and storage of tooling.
- A recommended planning guideline to minimize the variability introduced by the process planning function.
- A training plan describing all training requirements and recommending responsibility.
- A recommended flow plan/floor layout to support the new RCC design.
- A UDOS 2.0 (or later) model of the MDMSC recommended RCC design.
- A report describing the recommended personnel mix and work schedule, with supporting documentation.

MABPSC FOCUS STUDY CRITERIA CHECKLIST

TABLE 8.3.5-1 (SHEET 1 OF 2)

AREA OF ANALYSIS	ACTIVITY (WHAT & HOW)
Process/Material Flow	Outline sequence of process steps with proposed process. Identify critical points in process. *Identify critical points in process flow.*
Equipment/Work Place Layout	Develop plans for equipment and layout under new design.
Facility Requirements	Analyze requirements for proposed new layout.
Labor Standards	Provide information on new processes to MAB planners to update standards.
Manpower	Provide assessment of required manpower under new RCC design.
Task Assignments	Assess and define functions and tasks with proposed technology changes.
Material Requirements	Determine tooling support requirements. Propose a plan for meeting requirements.
Scrap Rates	Scrap rates are not currently tracked. No data available.

LSC-20606B

MABPSC FOCUS STUDY CRITERIA CHECKLIST

TABLE 8.3.5-1 (SHEET 2 OF 2)

AREA OF ANALYSIS	ACTIVITY (WHAT & HOW)
Material Handling & Storage Methods	Develop new material handling/storage plan.
Inspection Techniques	Examine current methods; propose specific changes, if required, for machine cutting.
Equipment/Tools/Fixtures	Define system requirements; assess utility of new equipment. Develop plans for procurement, modification, fabrication.
Process Delays	Provide critical path analysis of proposed system.
Part Identification	No impact.
Quality	Assess product quality under proposed plan.
Personnel Safety	Identify safety concerns with new processes.
Environmental Assessments	Not directly studied.

LSC-20606B

PROJECTED MDMSC ACTIVITIES

TABLE 8.3.5-2

STEP	ACTIVITY
1	Perform process planning study. Expand current process family groupings and identify the algorithms for selecting the process to be used. Provide the results to SA-ALC in the form of a deliverable planning guideline.
2	Identify the equipment which should be used to perform each process, based on quality requirements and projected workload.
3	Develop a plan for the acquisition/maintenance/replacement of equipment identified in step 2. Provide this plan to SA-ALC as a contract deliverable.
4	Perform a product flow analysis and develop a new flow plan/layout for MABPSC. Provide this to SA-ALC as a contract deliverable.
5	Assess the tooling requirements of the new equipment and develop a plan to meet these requirements. Submit the plan to SA-ALC as a deliverable.
6	Model the proposed RCC design using the UDOS 2.0 (or later) simulation model. Use this model to determine a recommended personnel mix and work schedule. Provide this data to SA-ALC as contract deliverables.
7	Identify the training required to support the recommended personnel structure. Provide a training plan to SA-ALC as a deliverable.
8	Provide a detailed CSR to SA-ALC as the final contract deliverable.

- Three monthly status reports, describing activities/progress to date.
- A final CSR, describing the results of the focus study and summarizing MDMSC recommendations for further action.

8.3.5.1 Rationale Leading to Change

During the characterization of MABPSC it was evident that the processes used to cut parts to size are inefficient. Experimentation performed in St. Louis using the UDOS 2.0 simulation model and validated MABPSC flat file (database) indicated a manhour savings of 3527 hours annually if the current manual operations of scribing and sawing are replaced by machine operations at least 50% of the time. Also, scrap and rework would decrease. (Scrap is not documented in this RCC, so this aspect of savings cannot be quantified by MDMSC with information presently available.)

Machine cutting improves the accuracy and quality of the parts cut. This focus study recommends an analysis of cutting task requirements to identify machines to replace manual effort.

8.3.5.2 Potential Cost Benefits

An annual recurring cost savings of $97,310 occurs from the implementation of the recommended improvements as shown in Table 8.3.5.2-1.

The investment cost of the recommendations is estimated at $225,000. This cost includes the focus study effort and the implementation cost.

The Cost Benefit Analysis (CBA) shows an Internal Rate of Return (IRR) of 32% and a savings of $143,332 in terms of Net Present Value (NPV) over five years using constant FY 89 dollars, see Figure 8.3.5.2-1. The CBA is in compliance with Air Force Regulation AFR173-15, cost analysis procedures, dated 4 March 1988 and rates per AFLC 78-3.

The CBA covers the time frame starting with the focus study through five years after the completion of implementation. The recurring cost savings was assumed to start at the end of implementation.

SUMMARY OF INVESTMENT COST AND ANNUAL SAVINGS (CONSTANT FY89 DOLLARS)
TABLE 8.3.5.2-1 (SHEET 1 OF 2)

	CURRENT ANNUAL COSTS	PROPOSED CHANGE: INVESTMENT COSTS	PROPOSED CHANGE: ANNUAL COSTS
NONRECURRING COSTS (1)			
FOCUS STUDY	$0	$170,000 (2)	$0
FACILITIES			
LAND	$0	$0	$0
BUILDINGS	$0	$0	$0
SUPPORT EQUIPMENT			
DEVELOPMENT	$0	$0	$0
ACQUISITION	$0	$50,000 (3)	$0
INSTALL & CHECKOUT	$0	$5,000 (4)	$0
LOGISTICS SUPPORT			
INITIAL SPARES	$0	$0	$0
INITIAL TRAINING (DEV & PRESENTATION)	$0	$0	$0
TECHNICAL DATA	$0	$0	$0
TOTAL NONRECURRING COST	$0	$225,000	$0
RECURRING COSTS (1)			
TOUCH LABOR	$3,052,227 (5)	$0	$2,954,917 (6)
SUPPORT EQUIP MAINT	$0	$0	$0
SPARES AND SPARES MGMT	$0	$0	$0
TECHNICAL DATA	$0	$0	$0
MOD KITS	$0	$0	$0
CONFIGURATION DATA MGMT	$0	$0	$0
UTILITIES	$0	$0	$0
TOTAL RECURRING COSTS	$3,052,227	$0	$2,954,917
TOTAL COSTS	$3,052,227	$225,000	$2,954,917
ANNUAL COST SAVINGS	$97,310		

NUMBER OF MONTHS FOR FOCUS STUDY	4
NUMBER OF MONTHS TO IMPLEMENT CHANGES	6

SUMMARY OF INVESTMENT COST AND ANNUAL SAVINGS (CONSTANT FY89 DOLLARS)
TABLE 8.3.5.2-1 (SHEET 2 OF 2)

NOTES:

(1) ONLY ITEMS THAT ARE SIGNIFICANTLY AFFECTED BY THE PROPOSED CHANGE HAVE BEEN ESTIMATED

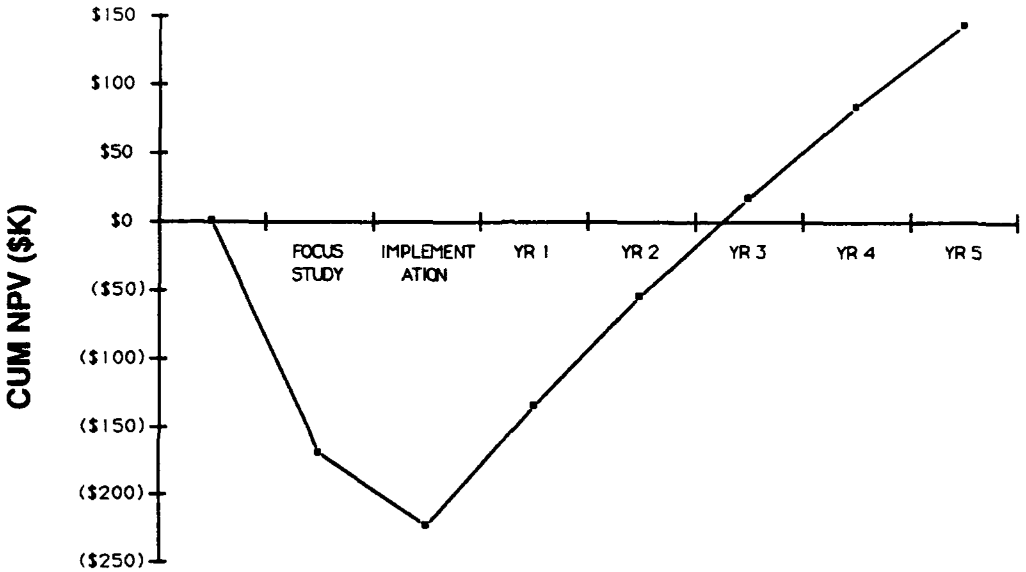
(2) ENGINEERING ESTIMATE FOR USE IN ENGINEERING TRADE STUDIES ONLY, DOES NOT REPRESENT FIRM PRICING

(3) ENGINEERING ESTIMATE (ROM) OF ACQUISITION COST FOR TOOLS AND EQUIPMENT.

(4) INSTALLATION COST IS ESTIMATED AT 10 PERCENT OF EQUIPMENT COST.

(5) CURRENT TOUCH LABOR FROM MODEL EXPERIMENTATION RUNS = 110,628 HOURS X $27.59/HOUR = $3,052,227.

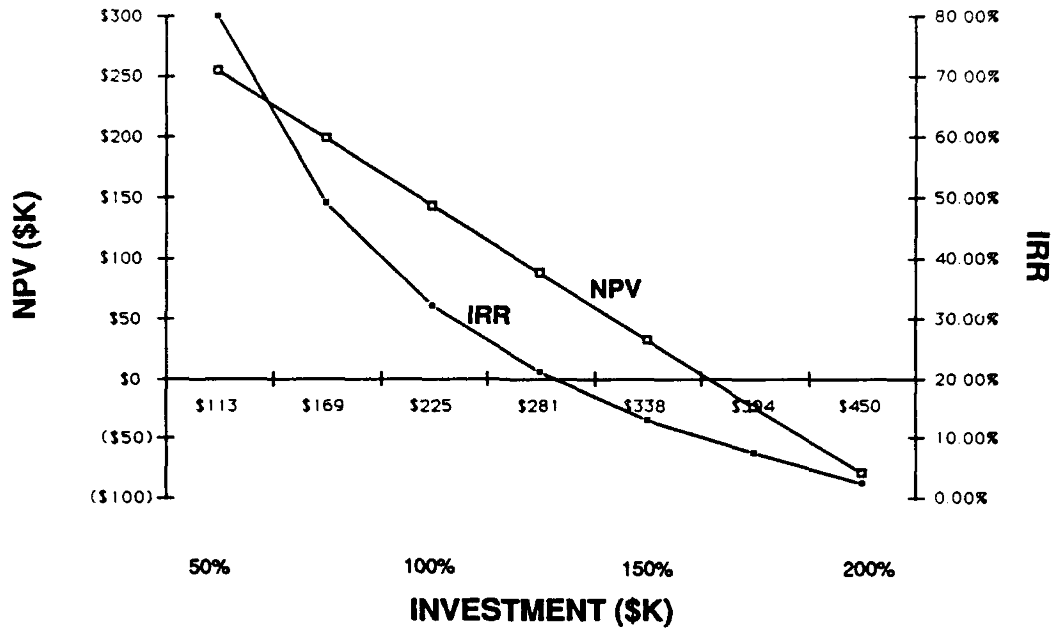
(6) PROPOSED TOUCH LABOR FROM MODEL EXPERIMENTATION RUNS = 107,101 HOURS X $27.59/HOUR = $2,954,917.



CUM NPV IN CONSTANT FY89 DOLLARS
FIGURE 8.3.5.2-1

The NPV takes into account the time value of money and is calculated by discounting a cash flow. The focus study cost, implementation cost, and the recurring savings were spread by fiscal year quarters and discounted back to the first quarter by using a mid-quarter discounting factor equivalent to an annual discount factor of 10%. Basically, this means a dollar that is earned in FY 90 is worth $.91 in FY 89 terms ($1.00/1.1), due to the ability to borrow or lend at a positive interest rate.

A sensitivity analysis was performed in which the investment cost varied between 50% and 200% of the estimated costs, see Figure 8.3.5.2-2.



CBA SENSITIVITY ANALYSIS
FIGURE 8.3.5.2-2

8.3.5.3 Risk Assessment of Achieving Goals

The proposed metal cutting technologies are in common use throughout private industry, as well as, other areas in AFLC. MATPIA at OC-ALC, for example, currently makes extensive (and effective) use of NC cutting and punching for sheet metal cutting in short-run manufacturing situations. MDMSC feels that there is no technological risk associated with this study.

Given the widespread use of machine cutting, and MDMSC's familiarity with the technology, MDMSC has high confidence in the reliability of the manpower and flow time savings estimates included in this focus study. A test of the effects of these changes, simulated on the UDOS 2.0 Model confirmed MDMSC's projections of results (see experiment 2, paragraph 8.1.2.2). MDMSC feels that the risk of the recommended changes not producing acceptable savings is very low.

As the type of capital equipment studied for procurement under this focus study is in common use both in and outside of AFLC, its cost to the U.S. government can be projected very reliably. This causes MDMSC to conclude that the risk of actual implementation costs exceeding the MDMSC estimates is very low.

Given the conventional nature of this focus study and the technology it proposes to study, MDMSC concludes that the risk of not achieving the study's goals is very slight.

8.3.5.4 Duration and Level of Effort

MDMSC proposes to perform this study in accordance with the schedule shown on Figure 8.3.5.4-1. The total period of performance will be four months from date of contract turn-on.

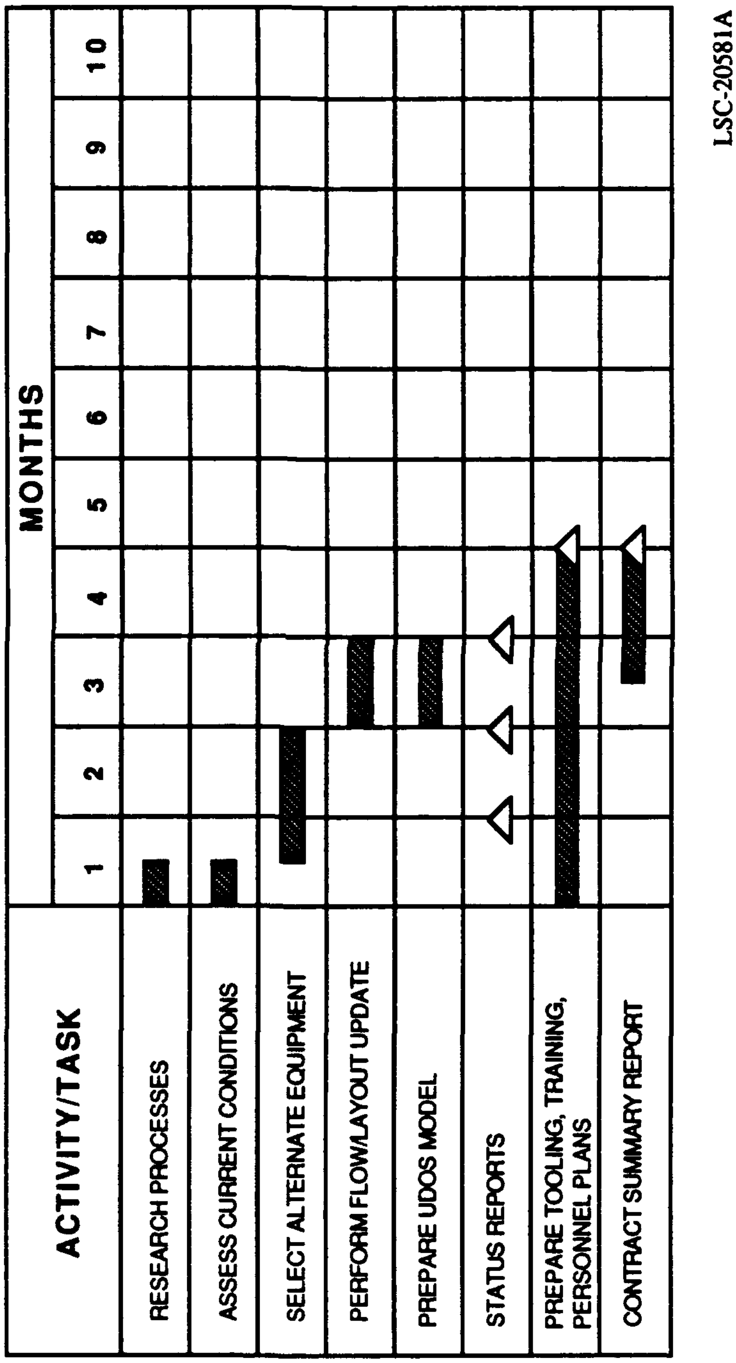
MDMSC proposes the following effort under this study:

One MDMSC tooling specialist 1/2 time -	308 manhours
One MDMSC simulation specialist 1/2 time -	308 manhours
Two MDMSC industrial/manufacturing engineers full time -	1232 manhours

It is estimated that $225,000 is required to successfully implement this recommendation. The number is an engineering ROM estimate for engineering trade studies only; it does not represent firm pricing.

8.3.6 Other Observations

The other observations described in this section are items identified by the SA-ALC/MDMSC TI-ES team considered important enough to comment on, but which are not quantified or quantifiable. Some were previously submitted as quick fix candidates.



PROPOSED FOCUS STUDY SCHEDULE

FIGURE 8.3.5.4-1

General Improvement Opportunities:

- Storage of Punch and Die Sets
  - Current Condition: As described previously in paragraph 8.3.1 Description of Current Operations, the storage and handling of punch and die sets is not adequate.
  - MDMSC Recommendation: Provide adequate storage racks and floor space so the tools can be organized in an orderly manner for easy access, location and storage. Also provide adequate floor space to permit use of material handling equipment to eliminate the manual handling of these heavy tools.
- Storage of Drop Hammer Dies
  - Current Condition: As described previously in paragraph 8.3.1, Description of Current Operations, the storage and handling of drop hammer die sets is not adequate.
  - MDMSC Recommendation: Install a vertical rack storage system for the die sets to eliminate the stacking of die sets on one another and the need to move other die sets to get to the one required. This problem is being investigated by a QP-4 Team.
- Hot Forming Machine
  - Current Condition: Parts are formed by hand and presses. The forming process work hardens the material and the part must then be annealed and heat treated. During the heat treating process the parts usually warp and need to be straightened.
  - MDMSC Recommendation: Procure a Hot Forming Press. This type of equipment heats the part during the forming process without degrading the hardness of the material. As a result, heat treating and straightening are eliminated. A Hot Forming Press is listed in the SA-ALC LIFT Plan and is proposed for procurement in FY 92. MDMSC concurs with this acquisition.

- Increase Production Hours for CNC Router - Accomplish Programming on Other Equipment
  - Current Condition: Any program tapes developed for the CNC Router are developed on the Router. The machine is not productive during this time.
  - MDMSC Recommendation: Find or develop another source capable of programming machine control tapes so the CNC Router can be used 100% for the production of parts.
- Provide Detail Planning to the Shop
  - Current Condition: Planning (MABEA) releases an L3A document which authorizes work to Scheduling which, in turn, releases it and a schedule to the Layout section of MABPSC. The Layout mechanic provides a generic WCD to the fabrication mechanic, but this WCD does not provide process steps in detail, nor does it specify which tools and equipment are to be used. The Layout mechanics are also responsible for providing to the mechanic tooling (pattern templates and form blocks), if available, from previous jobs, or make tooling if none is available.
  - MDMSC Recommendation: Planning should be provided in greater detail to specify how a particular part is to be fabricated, i.e., power equipment to be used, special tools required, processes to be followed or made by hand. This eliminates any work delay for decision making by the layout mechanic or the fabrication mechanic on how a part is to be made.
- Improve Deburring Capability
  - Current Condition: All deburring is accomplished by hand at this time using small belt sanders (approximately 24 available around shop). This is very labor intensive.
  - MDMSC Recommendation: Acquire a Deburring machine that deburrs parts automatically and eliminates the majority of hand deburring. This type machine can be operated by one mechanic and all deburring can be processed through this station.

- Perform Heat Treat Testing in MABPSC
  - Current Condition: Heat Treat samples are sent to MAQCM Lab for testing. This process normally takes one day.
  - MDMSC Recommendation: Provide MABPSC (Weld and Heat Treat Shop) with Rockwell Hardness Tester to perform hardness tests. This would save one day of flow time plus the time of the mechanics to transport samples to and from the MAQCM Lab.

8.4 MABPSP ANALYSIS AND FOCUS STUDY RECOMMENDATIONS

MABPSP is the Bonding and Plastic Unit Resource Control Center (RCC) within the Aircraft Division (MAB) component Repair Section (PS). It is responsible for repairing B-52 and C-5A sheet metal honeycomb structures, plexiglas, phenolic, PVC, fiberglass, and urlite components.

The current processes, facilities, equipment, and manpower found in the RCC are described in paragraphs 8.4.1.1 through 8.4.1.4. A description of the statistical experimentation is contained in paragraph 8.4.2.

8.4.1 <u>Description of Current Operation</u>

This paragraph summarizes the engineering assessment of the As-Is conditions within MABPSP. Where appropriate, it includes MDMSC recommendations for changes and identification of strong and weak points in the RCC's operation.

8.4.1.1 Current Processes

The primary workload of MABPSP consists of Management of Items Subject To Repair (MISTR). The 80/20 analysis performed for this RCC identified seven end items for characterization, including four Trailing Fdge Assemblies, two Slat Assemblies, and one Fuel Access Door Assembly. These items were selected by the 80/20 process from G019C file data provided by SA-ALC. Only sheet metal honeycomb structures were within the 80/20 workload guideline. Therefore, no plastic items were characterized. During 1988, this RCC performed a substantial amount of temporary manufacturing work under the PACER LIGHT program. This additional workload is no longer performed in MABPSP and, after consultation with RCC supervision, was not included in the characterization. As the MISTR has changed very little since 1988, the workload reflected in the model represents a realistic baseline of 80% of MABPSP work, and produced an acceptable model for the TI-ES validation team.

MABPSP is responsible for disassembly and repair/overhaul of sheet metal honeycomb structures and plastic items from the B-52 and C-5A aircrafts. The disassembly and repair work accomplished in MABPSP includes the repair and

replacement of doublers, ribs, angles, skins, longerons, channels, fittings, hooks, seals, and honeycomb using the anodizing, bonding, and autoclave processes. There are four major process areas in MABPSP that repair sheet metal honeycomb structures:

- Disassembly and Repair
- Anodize Tanks
- Lay-up
- Autoclaves

Parts are received from MABPAR, where they are stripped and cleaned prior to repair. The assemblies are disassembled by drilling out rivets, and removing screws, bolts, nuts, and fasteners. Further inspections are made to find hidden damage and/or corrosion. Detail parts are repaired or replaced and the assembly is then reassembled. Most of this work is accomplished with hand tools (hand drills, rivet guns, etc.).

Repair of the bonded/honeycomb portion of the assemblies requires specialized effort. Damaged skins are peeled off by hand with the use of many special hand tools. Damaged honeycomb is either replaced in sections or the entire piece is replaced.

All aluminum skins and detail parts must be processed through the anodize line to be cleaned and anodize-etched to prepare the surfaces for bonding. Cleaned and anodize-etched parts are then wrapped to prevent contamination from handling, and moved into the lay-up room for bonding.

Assemblies requiring bonding are also moved to the lay-up room. The skins, detail parts, and honeycomb are assembled together with sheets of adhesive or glass fabric impregnated with adhesive per Technical Orders. The assembly is placed on a specially-designed bonding fixture that matches the configuration of the assembly.

The assembly is then vacuum bagged to remove all air and moisture and is placed in the autoclave for curing. Assemblies cured at high temperature

require a 3.5 hour curing cycle while other assemblies cured at low temperature require a 4.0 hour curing cycle.

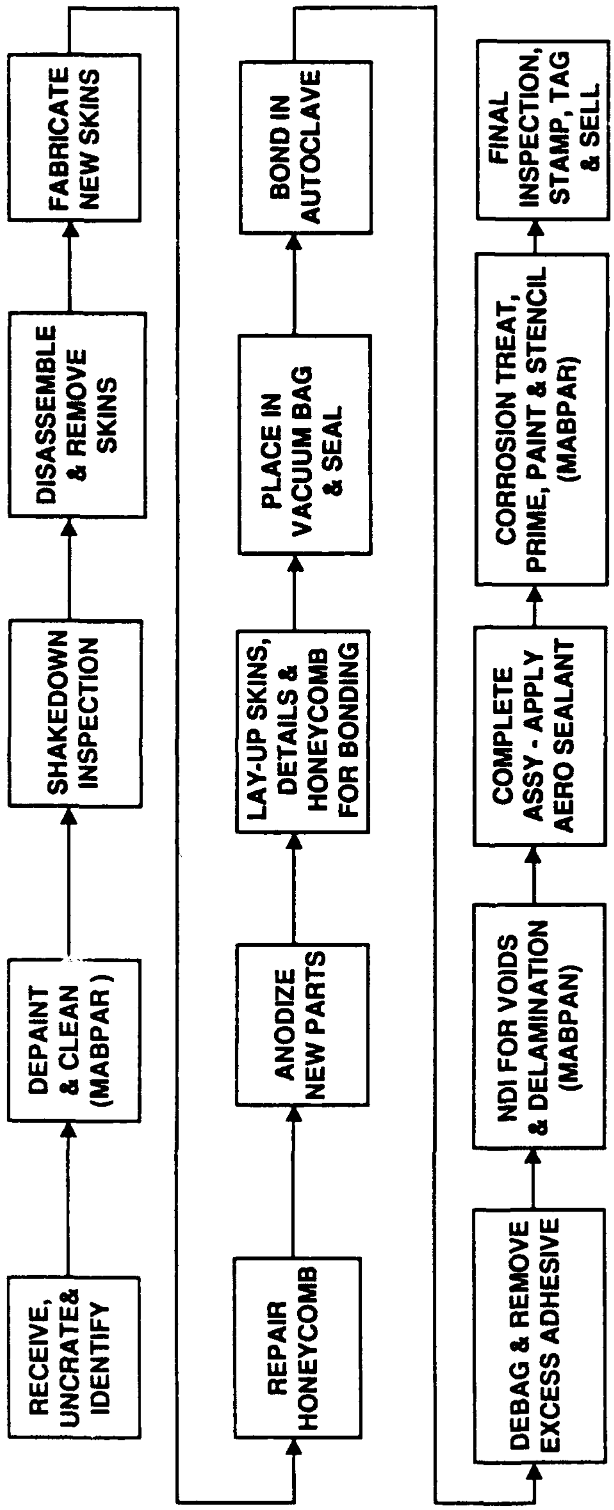
After the assemblies have completed the bonding process, they are debagged, excess adhesive is removed, and they are cleaned and tested for voids in the bonding. The assemblies are then sent to the back shop for corrosion treatment, prime, and paint. Assemblies are returned to MABPSP for any remaining required assembly, final inspection, tag, and sell. Process flow charts depicting repair processes are shown in Figures 8.4.1-1 and 8.4.1-2.

Most movement of parts/assemblies within the RCC is accomplished manually with the use of dollies and overhead cranes. The large parts have specially designed dollies to ensure safe movement. The smaller parts, e.g., fuel access door assembly, are moved manually without the aid of carts or dollies. Movement of large assemblies between MABPSP and back shops is accomplished with the use of the specially designed dollies pulled by tugs and/or forklifts. Incoming parts/assemblies are stored in several places: outside of Building 375 where parts/assemblies remain packaged, in Building 397 in close proximity to the RCC, and adjacent to the work areas, in quantities just large enough to keep the RCC supplied with adequate work.

8.4.1.2 Facilities

MABPSP repair areas occupy approximately 21,000 sq. ft. located in Building 375. The RCC's floorspace is divided into three major areas to repair and process the current workload. The disassembly and repair area has approximately 10,000 sq. ft. The east and west boundaries are between posts 26 and 30. The north boundary is the north wall of Building 375 and the south boundary is the aircraft hangar. MABPSP utilizes approximately 1,000 sq. ft. of the hangar area for repair of fairings.

The layout of MABPSP is good except for the disassembly and repair area which is crowded. The work areas are clean, orderly, and well-maintained. The layout drawing for MABPSP given to MDMSC is not current, does not reflect the latest configuration of the repair areas, and is not dated or signed. A copy of



PCN# 04004A	C-5A	SLAT ASSEMBLY
PCN# 05684A	C-5A	SLAT ASSEMBLY
PCN# 05694A	B-52G	FAIRING (TRAILING EDGE ASSY)
PCN# 05695A	B-52G	FAIRING (TRAILING EDGE ASSY)
PCN# 11514A	B-52G	FAIRING (TRAILING EDGE ASSY)
PCN# 11515A	B-52G	FAIRING (TRAILING EDGE ASSY)

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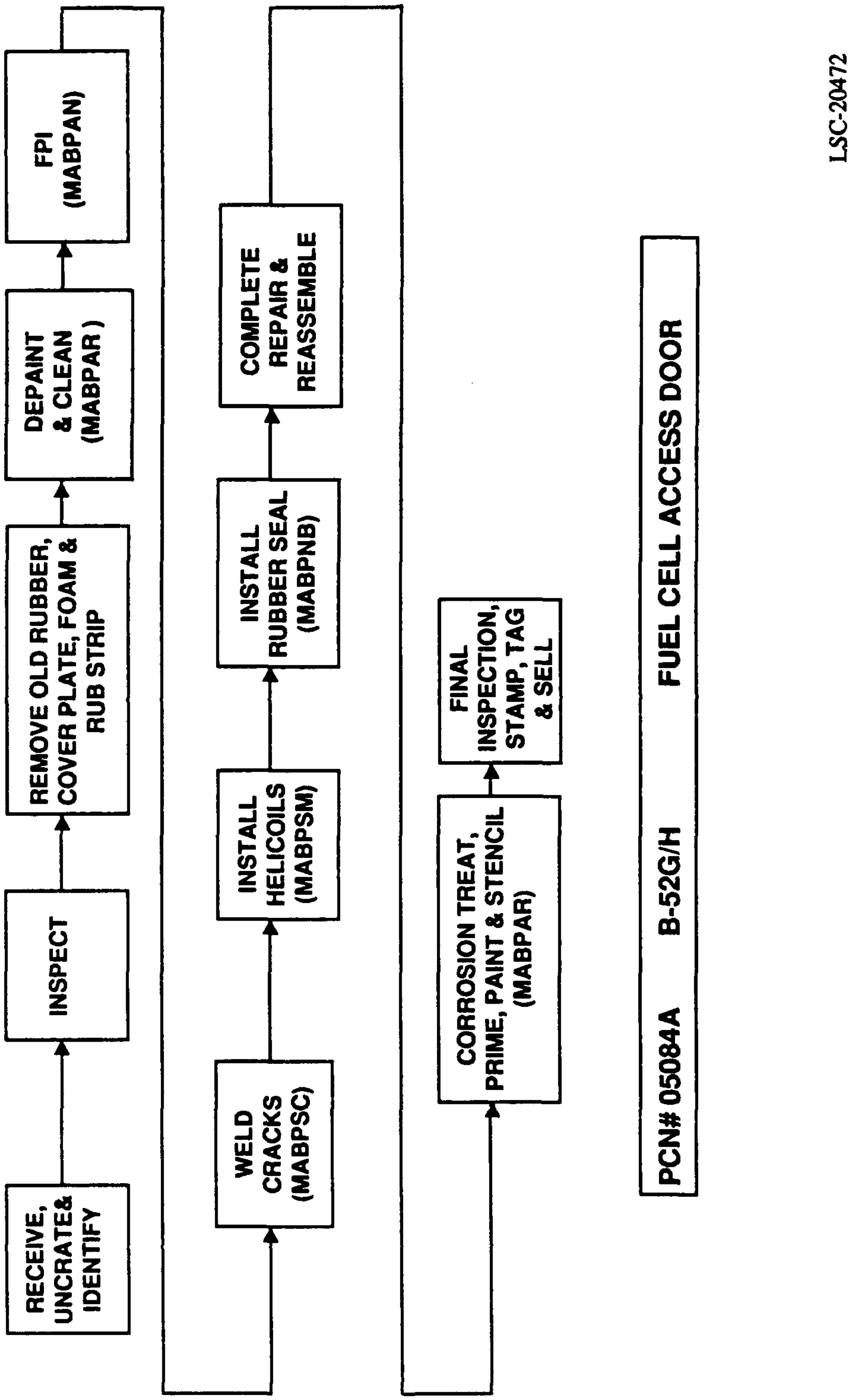
MABPSP PROCESS FLOW 1

FIGURE 8.4.1-1



MABPSP PROCESS FLOW 2
FIGURE 8.4.1-2

this drawing is included in the Database Documentation Book (DDB) for MABPSP.

8.4.1.3 Equipment

Equipment and tools used by the mechanics within the RCC consist of hand tools, pneumatic hand tools, simple holding fixtures, alignment fixtures, sheet metal fabrication equipment, bonding fixtures, anodize tanks, and two autoclaves. In addition, many special hand tools have been developed to facilitate the repair of honeycomb assemblies.

The holding fixtures are approximately thirty years old, and the average age of the alignment fixtures is five years. There are eight bonding fixtures and all appear to be in good condition. A new holding fixture designed to rotate the fairing (trailing edge assy) 360° about its horizontal axis is being developed to facilitate the repair of this item. A special roller for forming honeycomb has been developed by the RCC and the engineering staff, which will handle honeycomb up to 3" thick and 6' wide.

The equipment is very similar to that used by other job shop operations in the private sector and appears to be adequate for its intended purpose. Paragraph 8.4.4 recommends certain specific changes to equipment that would improve productivity.

The larger of the two autoclaves has interior dimensions of 15' x 60' and is used for the bonding process of the B-52G fairings and C-5A slats. Refurbishment of this autoclave was completed June 1989. Phase II of this project will upgrade the support facilities and has an estimated completion date of 1990.

Two carts/fixtures are used to load and unload the large autoclave. Their dimensions are 2-1/2' high x 25' long and 10' wide. The small autoclave has interior dimensions of 6' x 12' and is used for much smaller parts.

The anodizing line consists of seven dip tanks, dryer, baskets, and an overhead hoist system. This equipment was installed in 1981. Between 1981 and 1986

the system/equipment was plagued with numerous problems. Since 1986 the ALC has been resolving the problems and the equipment appeared to be in very good condition at the time of process characterization. The UDOS model showed generally low utilization of equipment, with no significant bottlenecks or queues.

8.4.1.4 Personnel

MABPSP manpower supporting the current workload consist of the following personnel:

		Quarter				Avg. Yrs. of
1st Shift		1	2	3	4	Experience
WT00	Apprentice	4	4	4	4	2
3806SE05	Mechanic Helper	31	31	34	34	4
3806SE08	Worker	7	7	10	10	8
3806SE10	Mechanic	34	34	38	38	12
	Sub Total	76	76	86	86	
2nd Shift						
WT00	Apprentice	-	-	-	-	-
3806SE05	Mechanic Helper	3	3	1	1	4
3806SE08	Worker	3	3	1	1	8
3806SE10	Mechanic	6	6	2	2	12
	Sub Total	12	12	4	4	
	Grand Total	88	88	90	90	

There are five Supervisors (WS3806SE10) and one RCC Chief (WS3806SE14) responsible for the supervision of above listed personnel. The work force is stable with no significant fluctuations in head count. They are generally well-trained, knowledgeable of the repair processes, and work with a minimum of supervision. Manpower utilization in the UDOS model was generally very low (8-19%) on first shift. This is discussed further in paragraph 8.4.2.1.

While these mechanics are divided into several wage grades, there is a great deal of interchangeability among them.

8.4.1.5 Explanation of Current Success

MABPSP is currently meeting all production requirements. The reasons for this success are quite straight forward. MABPSP has sufficient workers, using adequate tools, maintaining sufficient inventory levels to meet all requirements. Surge experiments with UDOS (see paragraph 8.4.2.4) indicate that, with appropriate shift work, MABPSP can meet all projected wartime surge requirements as well, with no additional resources.

As described in paragraph 8.4.2.1, utilization rates for equipment and manpower are lower than in many RCCs. This appears to be a function of scheduling, however, rather than excess equipment or personnel. This is addressed further in paragraphs 8.4.2.3 and 8.4.3.

The inventory WIP levels in this RCC are slightly higher than those found in most commercial overhaul centers, but are substantially lower than in most other RCCs in SA-ALC. There are no significant delays in the processes of those PCNs characterized and no obvious queues or bottlenecks. Floorspace, though tight, appears to be adequate for the work at hand. This is discussed further in paragraph 8.4.3.

8.4.2 Statistical System Performance Measure

A joint MDMSC/SA-ALC team met 24 July - 3 August 1989 to validate all Block II and III UDOS 2.0 simulation models, including MABPSP. This was accomplished by comparing simulated flow times and throughputs to historical data, G019C standards data, and MABPSP supervisory estimates. Other areas, such as process flow, resource utilization, and location of queues were examined as well, in accordance with the UDOS 2.0 acceptance test procedure previously delivered. Details of the validation can be found in the validation meeting minutes and in section 8.0 of the MABPSP DDB.

A common brainstorming session for all Block II and Block III RCCs was conducted at the conclusion of the validation. The ideas collected were reported in Appendix A of the validation minutes. The Taguchi orthogonal array and the experimentation were completed by MDMSC in St. Louis.

During the brainstorming session, the bulk of the significant factors identified for experimentation involved a potential reduction in operation times for processing all PCNs. During the MDMSC analysis of the validated model output, however, other significant areas for investigation were identified. As a result, two areas of experimentation were selected for this RCC. The first, described in paragraph 8.4.2.2 examines the effects of improved operation flow times by conducting multiple experimental runs at various levels of improvement. The second, described in paragraph 8.4.2.3 uses a Taguchi L_4 orthogonal array and conducts multiple experimental runs to evaluate the effects of changes in equipment quantities and shift schedules. Because of the dissimilarity between the types of changes examined, MDMSC elected to separate the experiments into two areas.

8.4.2.1 Statistical Analysis of Current Conditions

The current configuration of MABPSP produces an average throughput (number of parts out/number of parts in x 100) of 100% when modeled on UDOS 2.0 (see Table 8.4.2.3-2, experiment #1). Throughput by PCN ranges from 04004A (108%) to 05684A (93%). The most significant reason for throughputs less than 100% is the occurrence of long back shop times.

Equipment utilization is relatively low, with average utilizations in the 1% to 37% range. This low utilization rate is a function of the specialization of most pieces of equipment, and does not appear to indicate excess equipment. Under surge conditions, utilization rates only increased to the 4% to 77% range. No significant queues occur at any piece of equipment under normal or surge conditions.

Manpower utilization for the primary skill areas averaged only 8% to 19% on first shift, but was 74% to 92% on second shift (only 9% of the work force is on

second shift). This low first shift utilization does not appear to indicate an excess of personnel, but rather, an inefficient shift schedule. This is addressed further in paragraphs 8.4.2.3 and 8.4.3.

No significant bottlenecks were observed in this RCC, under normal or surge workload conditions. Under normal workloads, parts waited an average of only 3% to 16% of their total flowtime. Under surge conditions, this rose to the 3% to 50% range, although shift work reduced it to a maximum of less than 20%. This is significantly lower than most other RCCs in the command.

Back shop times had a much greater effect on flowtime/throughput than delays in MABPSP. Parts spend anywhere in the range of 8% to 97% of their total flowtime in a back shop. As described in paragraph 8.4.2.2, this indicates the critical importance of back shops to MABPSP's production process.

8.4.2.2 Area 1 Experimentation - Operations Improvement

A number of the ideas for experimentation that were suggested affect the length of time it would take to perform the operations on the WCDs. These ideas were presented in broad terms and included:

- Age of equipment - if newer equipment were available, operation times could be shortened.
- Quality of equipment - if the equipment that were purchased were of a better quality, operation times could be shortened.
- Newer and better hand tools - the same arguments for equipment held for hand tools.
- Better selection of personnel - if new hires were more trainable for their positions, the length of time it took to perform operations would be shortened. It was felt that the quality of incoming personnel was not what it should be.

As only rough estimates of the effect of each idea were available, MDMSC decided to test the overall effects of reduced operation times on the RCC. A set of experiments were run with all of the operations reduced by a specified

percentage. The purpose of these experiments was to see if the reduction would have a large effect on the flow times for the RCC.

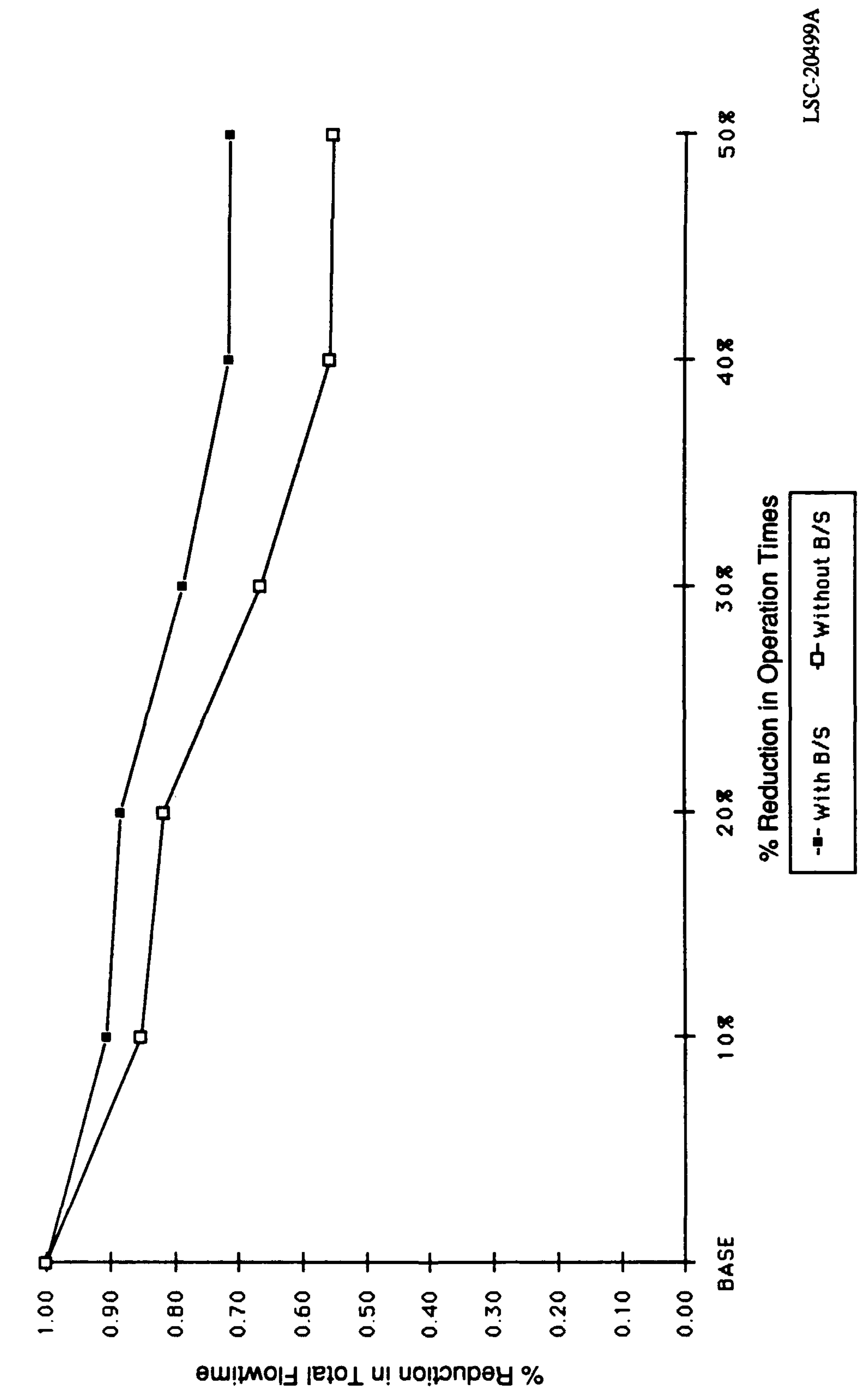
The experimentation was set up to compare the flow times from six runs. The description of he runs are:

- The Baseline data.
- The Baseline with all processing operations reduced by 10%.
- The Baseline with all processing operations reduced by 20%.
- The Baseline with all processing operations reduced by 30%.
- The Baseline with all processing operations reduced by 40%.
- The Baseline with all processing operations reduced by 50%.

A summary of the flow times by item and the average back shop hours are shown in tables in the Experimentation section of the DDB. A total flow time for the RCC was calculated and a percentage reduction from the baseline was calculated for each run. A similar calculation was made with the back shop times excluded from the flow times. The results are shown in table form in the Experimentation section of the DDB and graphically in Figure 8.4.2.2-1.

The results indicate an approximately linear reduction in flow times with the corresponding reduction in operation processing times. The reduction in flow times is the result of smaller operating times and smaller queue times. Since none of the items showed large queue times, the linear reduction is not surprising.

Back shop times for items 05894A, 05895A, 11514A, and 11515A are approximately 30% of the flow time and for item 05084A approximately 90% of the overall flow time. Concentrating on reducing the back shop flow times [notably MABPAR, the paint shop] would be a better approach for reducing overall flow times. Since many RCCs send items to MABPAR, any improvement in it will affect many RCCs. This is further addressed in paragraph 8.4.3.



EXPERIMENTATION WITH REDUCED OPERATION TIMES
% OF BASE FLOW TIMES FOR MABPSP
FIGURE 8.4.2.2-1

8.4.2.3 Area 2 Experimentation with Taguchi Methodology

The array selected for experimentation was an L_4 Taguchi orthogonal array with two levels of two factors and an interaction between the factors. The array is shown in Table 8.4.2.3-1. The four normal experimentation runs were performed by MDMSC at St. Louis using MDMSC computer resources. The simulated flow time and throughput were collected and analyzed for each of the seven PCNs characterized in MABPSP. An overview of experimentation results is summarized in Table 8.4.2.3-2. Detailed analysis sheets are included in section 10.0 of the DDB for MABPSP. The conclusions reached from analysis of the normal workload experiments are as follows:

- The current configuration of all resource in the RCC is sufficient to meet normal workloads. The flow times are unnecessarily long causing a large work-in-process inventory. The use of three shifts (Factor A), using the same number of personnel, produced an average reduction in flow times of 25 percent.
- The addition of three pieces of equipment, one each of the most heavily utilized in the RCC (Factor B), produced an average reduction in flow times of only six percent.
- The interaction (Factor C) between Factor A (shift work) and Factor B (extra equipment) was specifically tested. No significant interactions were found between these factors.

8.4.2.4 Surge Analysis

Two surge experimental runs were made; one with the current baseline configuration, and another with all personnel divided into two 12-hour shifts. The results were as follows:

- The current configuration in the RCC lacks sufficient capacity to meet surge workloads. The most significant factor in this area is the shortage of manpower.
- The best Taguchi projection (based on the factors tested) for this RCC indicated that, while going to three-shift operation would improve performance, it would not be sufficient to meet surge needs, therefore, 12-hour shifts were used.

MABPSP L_4 TAGUCHI ORTHOGONAL ARRAY

TABLE 8.4.2.3-1

NORMAL WORKLOAD

RUN	A SHIFT WORK	B EQUIPMENT	C AxB INTERACTION
1	AS-IS (1)	BASELINE (1)	$A_1 \times B_1$ (1)
2	AS-IS (1)	BASELINE "+" (2)	$A_1 \times B_2$ (2)
3	3 SHIFTS 1/3+1/3+1/3 (2)	BASELINE (1)	$A_2 \times B_1$ (2)
4	3 SHIFTS 1/3+1/3+1/3 (2)	BASELINE "+" (2)	$A_2 \times B_2$ (1)

SURGE WORKLOAD

RUN	A SHIFT WORK	B EQUIPMENT	
1	AS-IS	BASELINE	N/A
2	2 12-HOUR SHIFTS	BASELINE	N/A

EQUIPMENT:
BASELINE = AS-IS
BASELINE "+" = AS-IS PLUS 1 SP-4, 1 SP-10, 1 SP-12

NOTE: FACTOR C WAS TESTED AND THERE WERE NO SIGNIFICANT INTERACTIONS. THEREFORE, THIS COLUMN IS DISREGARDED.

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MABPSP $L_4(2^3)$ TAGUCHI ORTHOGONAL ARRAY THROUGHPUT EXPERIMENTAL RESULTS - FY 88

TABLE 8.4.2.3-2

EXP #	SHIFT WORK	EQUIPMENT QUANTITY	AxB INTERACTION	NORMAL WORKLOAD AVG	NORMAL WORKLOAD BEST	NORMAL WORKLOAD WORST
1	AS-IS	BASELINE	N/A	100 %	04004A 108%	05684A 93%
2	AS-IS	BASELINE +	N/A	97 %	04004A 117%	11514A 94%
3	3 SHIFTS 1/3, 1/3, 1/3	BASELINE	N/A	99 %	04004A 117%	05684A 88%
4	3 SHIFTS 1/3, 1/3, 1/3	BASELINE +	N/A	99 %	04004A 117%	05684A 88%

				SURGE		
SURGE 1	AS-IS	BASELINE	N/A	80 %	05684A 103%	05894A 40%
SURGE 2	2 12-HOUR SHIFTS	BASELINE	N/A	96 %	05684A 107%	05894A 86%

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- The final surge run, with all personnel divided into two 12-hour shifts, produced acceptable performance. This was without adding people or equipment.

8.4.2.5 Conclusions and Recommendations

MDMSC concludes that MABPSP has sufficient resources to meet all current and projected workloads, including wartime surge. MDMSC offers the following recommendations for consideration by MABPSP management:

- The use of multiple shifts should be considered to reduce flow times and reduce work-in-process.
- For surge, schedule all personnel on two 12-hour shifts without adding personnel.
- Based on the results of experimentation, no new capital equipment need be purchased for this RCC.
- Future AFTI efforts should include the process characterization of those areas which are a back shop to MABPSP. MABPAR should be selected first.

8.4.3 Description of Process Problems

MABPSP has no obvious process problems. Overall capacity, is sufficient to meet even projected surge workloads. The processes are simple manual repair operations with little interaction and no critical path. Actual "acceptable" flow times are determined by the requirements/schedule of the aircraft PDM line(s) supported by MABPSP. Without an assessment of these lines, MDMSC cannot provide a realistic assessment of the importance of a flow time through the RCC. While personnel in the RCC complained of parts shortages, MDMSC was unable to identify any situation where aircraft were delayed because of a delay in MABPSP. Two problems were identified, however, in the management of MABPSP's production process.

The first problem was in the amount of time parts spent in MABPAR as a back shop. It appears that 8% to 97% of the total flow time through MABPSP is not under the control of MABPSP management. This severely limits the ability of the MABPSP work force to implement process improvements. MABPAR

appears to be a more rewarding candidate for process characterization than MABPSP.

The second problem is a common one throughout the command. Actual data on process times and flow times is seldom captured, and thus, cannot be used to manage the RCC or evaluate potential improvements. While the completion of each operation should be dated on the WCD attached to the part, this is frequently overlooked by the mechanic. This lack of actual data makes it extremely difficult for MABPSP management to assess the impact of delays for engineering, tooling, planning, etc., or to quantify the cost of these delays. They can complain about problems, but they cannot provide the quantifiable data needed to justify a possible solution.

8.4.4 Other Observations

The other observations described in this section were not considered as focus studies or quick fixes because they had a less significant impact in the areas of time, quality, or cost. These observations are recorded to assist SA-ALC in developing ideas that will further enhance their operations.

General Improvement Opportunities:

- Vacuum/Exhaust System
  - Current Condition: Residual adhesive from the debonding process is removed manually, using motor driven sanding equipment. This method creates much dust in the air which may contain glass fiber. It causes discomfort (skin irritation) for anyone close by and may be harmful to lungs. A specially-designed sanding room was proposed approximately four years ago, but has not yet been implemented.
  - MDMSC Recommendation: Designate an area, preferably isolated from the open shop area, with a down draft vacuum and/or exhaust system is recommended to eliminate this problem. Enclosing this operation would eliminate environmental pollution with the dust.

- Hi-Lok Installation Guns
  - Current Condition: There are approximately 120 Hi-Lok fasteners used on a C-5A Slat Assembly. These fasteners are assembled by hand using allen and box wrenches, or allen and socket wrenches.
  - MDMSC Recommendation: Provide Hi-Lok guns to perform this operation. Considerable time will be saved and operator fatigue will be reduced. Note: A Form 1000 Employee Suggestion has been submitted by an RCC mechanic based on MDMSC's observation.
- Cleaning and Paint Stripping Facility
  - Current Condition: All cleaning and paint stripping is accomplished manually on each individual part or assembly. This is a time-consuming process and requires numerous operators to handle the existing workload.
  - MDMSC Recommendation: Install an automatic system that passes all parts and assemblies through a pressurized solvent and water system similar to an automatic car wash. This observation deals with a back shop and not MABPSP, but directly affects the process flow time of parts and assemblies being repaired by MABPSP and several other RCCs.
- Cherry Rivet Installation Guns
  - Current Condition: The heads of the existing cherry rivet guns break under constant use. This problem already has been identified by the RCC.
  - MDMSC Recommendation: Use heavy duty guns to lessen equipment downtime and operator frustration. Note: Heavy duty guns have been ordered by the RCC.

8.5 MATPGB ANALYSIS AND FOCUS STUDY RECOMMENDATIONS

The Gas Turbine Engine (GTE) overhaul Resource Control Center (RCC) - MATPGB - performs engine disassembly, subassembly, final assembly, and test operations on GTEs. The current processes, facilities, equipment, and manpower found in this RCC are described in paragraphs 8.5.1.1 through 8.5.1.4. A description of the statistical experimentation is described in paragraph 8.5.2.

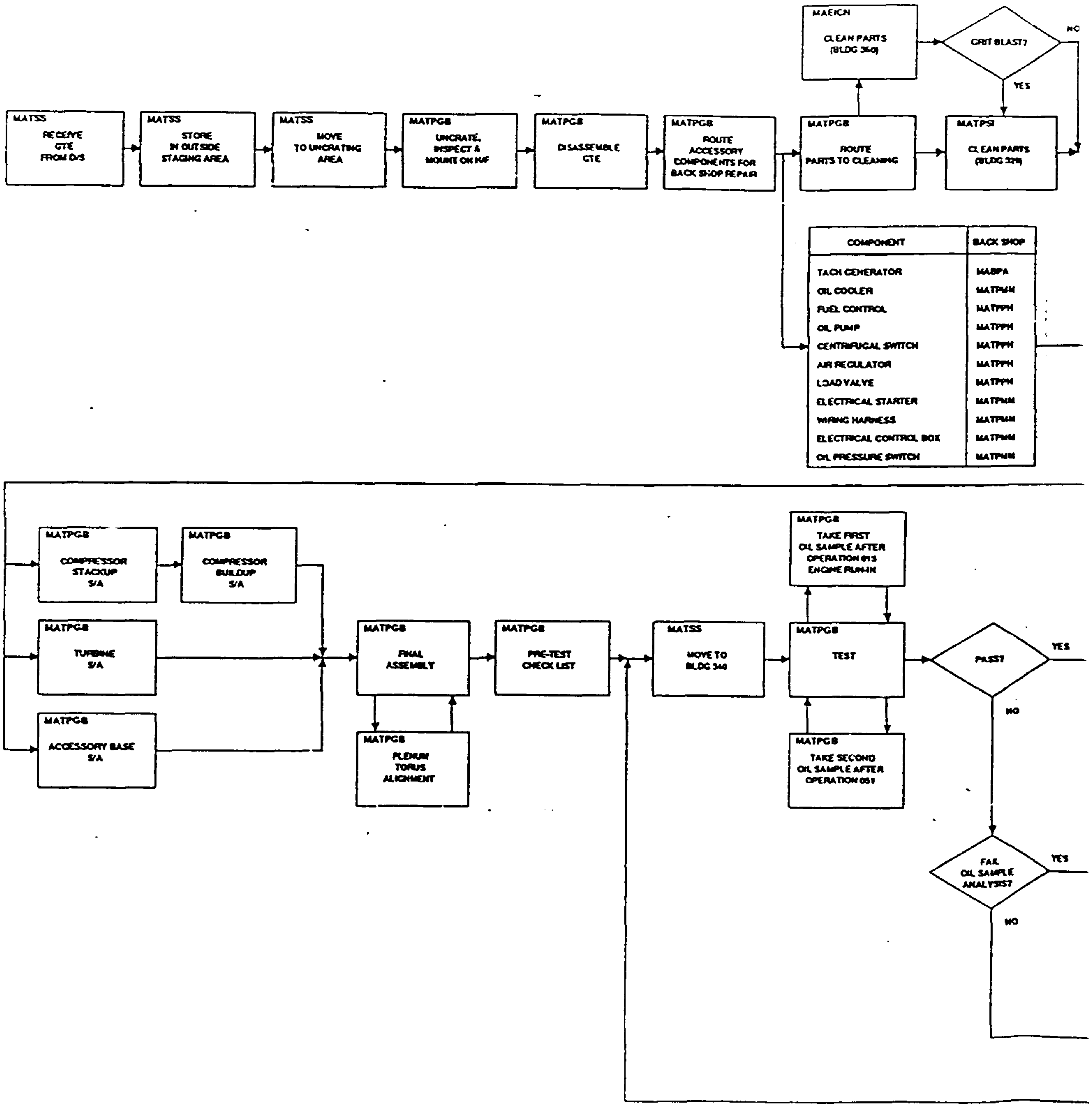
8.5.1 Description of Current Operation

This paragraph summarizes the engineering assessment of the As-Is conditions within MATPGB, including processes, facilities, equipment, and personnel. Where appropriate, it includes MDMSC recommendations for changes and identification of strong and weak points in the RCC's operation.

8.5.1.1 Current Processes

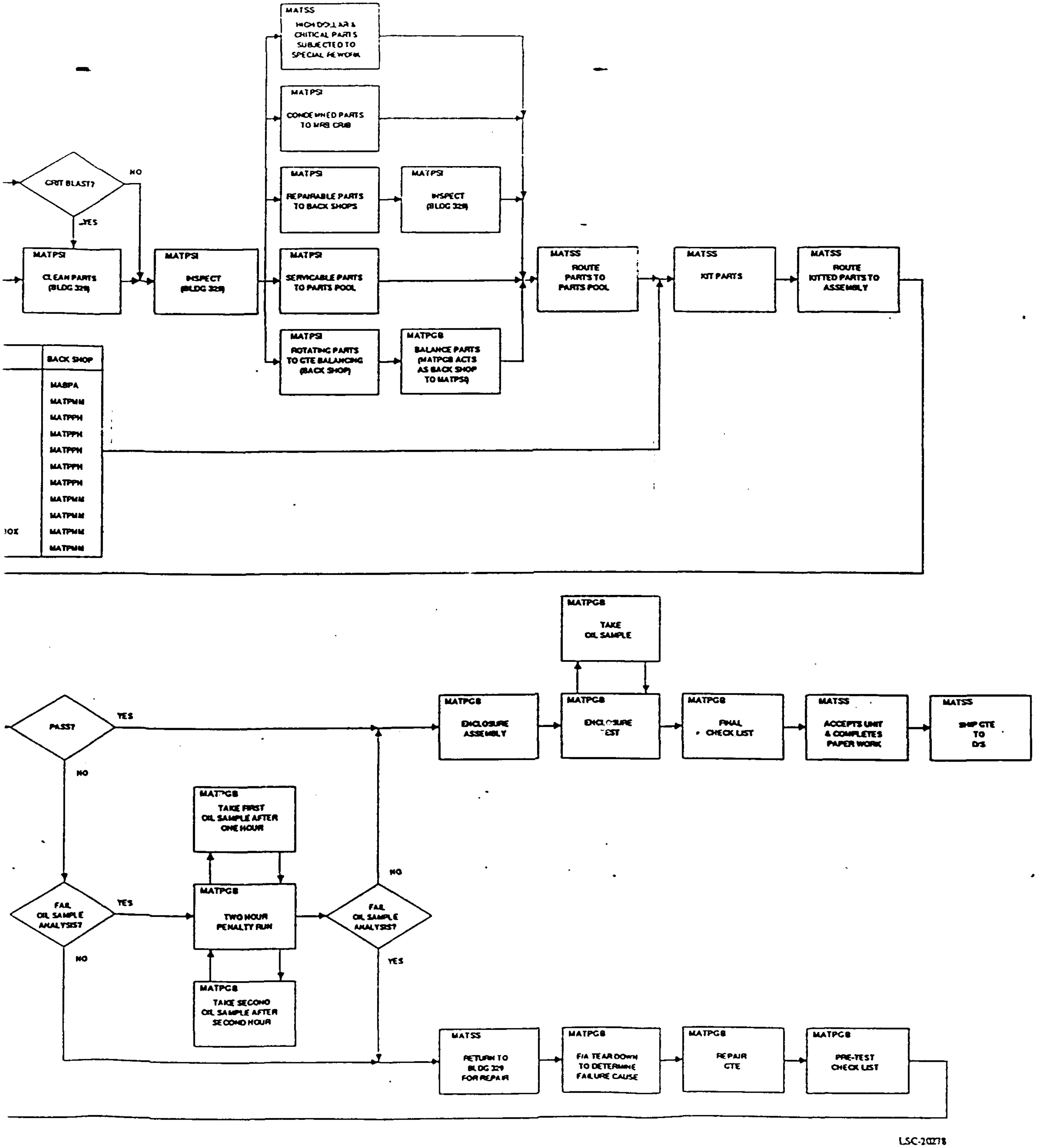
Workload in MATPGB is divided between Programmed Depot Maintenance (PDM) and Management of Items Subject to Repair (MISTR). Repair processes of three MISTR GTEs have been selected by 80/20 analysis for process characterization. They are: GTE 85-70A, (Part Control Number (PCN) 13081A); GTE 85-397 (PCN 13094A); and GTE 85-180 (PCN 130095A). This selection process is described in detail in section 3.0 of the DDB. Typically all GTEs required for one quarter's production are inducted at the end of the previous quarter. MATPGB is responsible for disassembly, repair/overhaul, and reassembly of GTEs. The current process flow for these items is shown in Figure 8.5.1-1.

GTEs are brought into an open bay on the east side of Building 329 where they are unpacked and mounted on work stands. The mounted GTEs are then pushed manually to the GTE area located in the north end of an enclosed, air conditioned disassembly room. The disassembly is generally organized by the type of engine being processed. Most disassembled parts and subassemblies are placed in plastic "egg carton" baskets. Parts requiring paint stripping and other chemical cleaning are placed in larger metal baskets and taken to the loading dock for MAEINC cleaning (Building 360). During disassembly,



GTE PROCESS FLC

FIGURE 8.5



OCESS FLOW (SA-ALC)
FIGURE 8.5.1-1

identification plates are removed and placed in plastic document bags which are then forwarded to Scheduling. MDMSC feels this last practice is extremely questionable and offers further detail in paragraph 8.5.3.

Parts are then moved to cleaning in either Building 329 or Building 360. Disassembled hardware items are cleaned, kitted and sent to the parts pool. After cleaning, those parts requiring balancing are sent to MATPGB per MATPSI WCD.

Following cleaning and inspection, serviceable parts go to the MATSS GTE parts pool, repairable parts are sent to back shop for repair, and condemned parts are sent to a condition review crib for disposition. The disassembly process is relatively straightforward, and depends primarily on labor-intensive tasks using common hand tools and simple holding fixtures. This portion of the MATPGB process has no significant bottlenecks or process problems.

The assembly portion of the process is more complex. The requirements for labor and equipment are generally similar to that of disassembly, but the material requirements are vastly greater. The GTE kits stored in MATSS and assembled by MATPGB are frequently incomplete, causing the assembly mechanic to rob parts from other kits (increasing the problem), draw parts from one of the "unofficial" or official bench stocks maintained in MATPGB, or to order new parts. When a GTE is stalled in assembly for a lack of parts, the workers normally induct another kit and begin the process again. This produces an enormous volume of Work In Process (WIP) in the assembly area. This problem is discussed in much greater detail in paragraph 8.5.3 and is the same problem encountered in MATPSS and MATPSI, as described in their respective paragraphs.

The GTE testing process is another portion of the process with significant problems. As described in paragraph 8.5.2, this area is currently the most significant bottleneck in the MATPGB process flow.

When an engine is received for test, it is removed from its transport pallet, installed on a four-wheeled test stand, and then moved into the test cell. During the GTE test run, oil samples are taken twice and sent to a laboratory. During that time, the engine is rolled from the test cell to a holding area where it is safety-wired. If the oil test is satisfactory, the lab telephones the test foreman that the engine is okay, whereupon the engine is rolled to another area at the south end of Building 340 where final documentation is attached. Once documents are attached, MATPGB regards the engine as "sold."

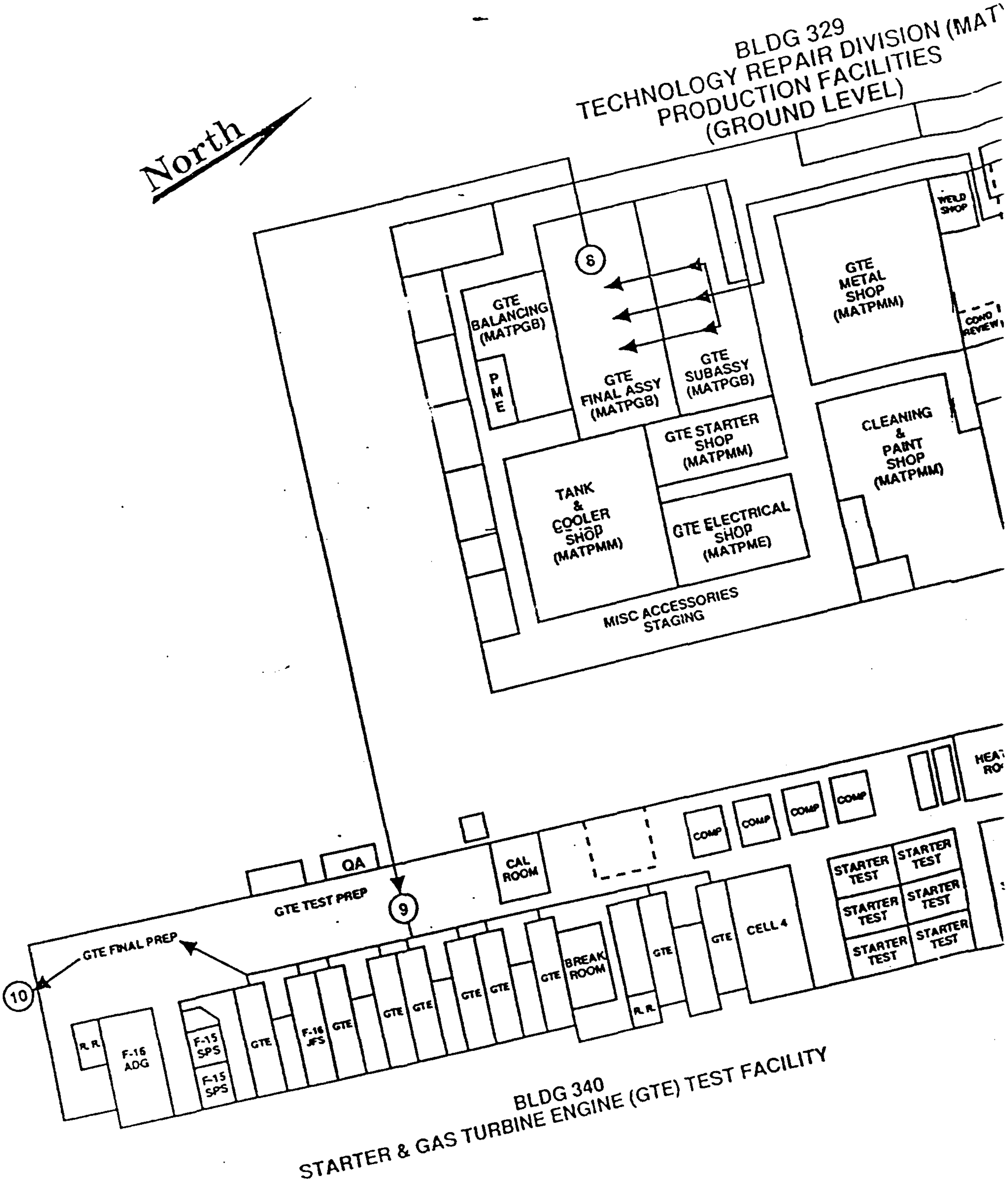
If an engine fails during test, it is recycled through the entire MATPGB process. Only a very limited amount of corrective maintenance is performed at the test stand. Failure rate estimates provided to MDMSC ranged from 10% - 15%. While the test cell computer equipment (described in paragraph 8.5.1.3) allows the capture and reporting of a great deal of test failure data, the practice of removing serial ID plates from GTEs renders most of this data useless. General failure trend data is available, however, and indicates that approximately 10% of the rejects are due to oil sample failures and the bulk of the remainder due to excessive vibration. This rejection rate would be considered extremely high in most commercial operations (including MDMSC) and appears to indicate a process problem. This is discussed in greater detail in paragraph 8.5.3.

8.5.1.2 Facilities

MATPGB occupies approximately 33,000 square feet of floorspace in Building 329 and 14,500 square feet in Building 340. All disassembly, repair, and assembly occur in Building 329 while all testing of assembled GTEs is performed in Building 340.

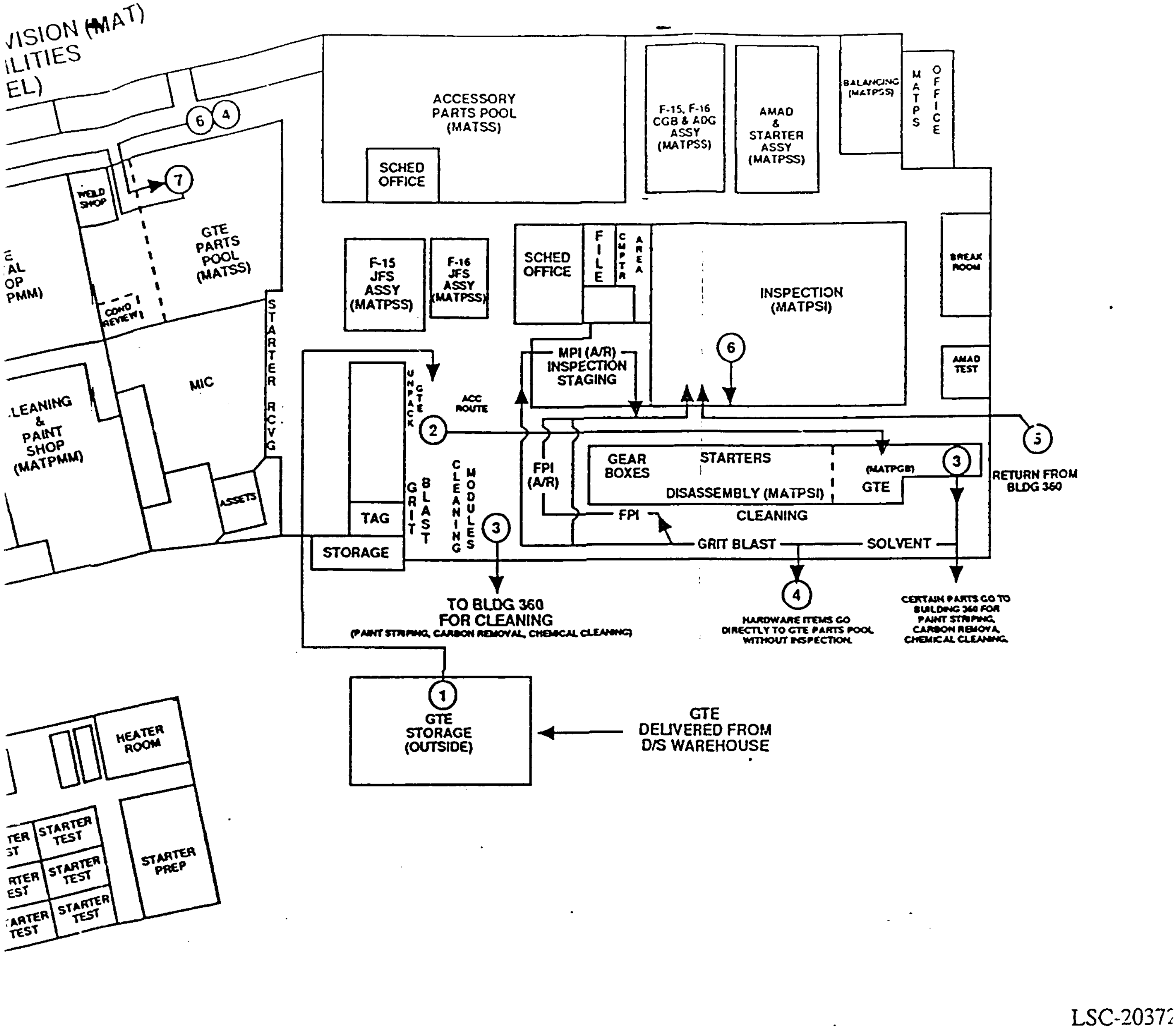
The layout drawings provided to MDMSC are current regarding the allocation of floorspace to MATPGB, but do not always reflect the existing locations of equipment. A copy of these layout drawings is shown under Figure 8.5.1-2.

Building 329 is shared with MATPSS and MATPSI, as well as the MATSS parts pool. Kitted parts are sent from the MATSS parts pool to MATPGB



MATPGB PRODU(

FIGURE



3 PRODUCT FLOW (SA-ALC)

FIGURE 8.5.1-2

subassembly and final assembly located at the south end of Building 329. Both functions are in free standing, enclosed modules with air conditioning.

The final assembly room has four build-up areas separated by workbenches or, in one case, a wall partition. Selected engines are assigned to each area due to specific assembly stands and bench stock requirements.

Building 340 is an old, pre-World War II vintage building. It contains, among other facilities, eleven GTE test cells, two of which are inoperable. The test chambers are separated from the instrument and control room by a thick wall with a thick safety window. Funding has been requested to construct a replacement building for Building 340. (Beneficial occupancy is expected in 1992.) This modernization is one part of SA-ALC's LIFT Plan. MDMSC's recommendations regarding this funding request are included in paragraph 8.5.2.4.

Other than a transportation problem between Buildings 329 and 340 (described in paragraph 8.5.5), no significant facilities-related process problems were observed. While MDMSC estimates that 33,000 square feet of the approximately 165,000 square feet of floorspace (20%) in Building 329 is used to store WIP, sufficient space remains to support the current level of production. MDMSC model experimentation indicates that approximately 60% more WIP will be required to support surge workloads (see paragraphs 8.5.2.3 and 8.5.2.4). This means that under surge, an additional 20,000 square feet will be required to meet production goals. One solution to this problem is offered in the focus study recommendation "Reduction of Parts Inventory and Improvement in Flowtime/Throughput" described in paragraph 8.5.4.

8.5.1.3 Equipment

The equipment used in the disassembly and assembly processes consists largely of hand tools and various holding fixtures. Utilization (in the UDOS model) of this equipment was very low (below 20%) and no significant queues were generated by this equipment. MDMSC's observations support the

modeled results and MDMSC concludes that there are no equipment-related process problems in the assembly/disassembly areas.

The material handling equipment in MATPGB is adequate to meet current production needs. Most transport between disassembly, parts pool and assembly is by roller-conveyor, rolling work stand or hand carry. The conveyors seldom move and are constantly clogged with WIP. This situation is addressed in more detail in paragraph 8.5.3.

After assembly, four 500 lb. capacity double transverse overhead chain hoists are used to lift the engines off the stands and on to brackets bolted to wooden transportation pallets on the floor. The engines are then moved by pallet-jack to the corridor outside the assembly room. A forklift is then used to transport the engines to Building 340 for testing. Problems associated with this inter-building move are detailed in paragraph 8.5.5.

The only significant equipment problem in MATPGB is the test cell capacity problem in Building 340. As demonstrated by UDOS experimentation (see paragraph 8.5.2.2), test cell capacity is the single most significant restriction in MATPGB's production capacity.

The computerized system that supports testing in these cells is a modern and effective system. Designed and implemented by SA-ALC personnel under the PACER COMET program, this system helps reduce the flowtime across the test cells and is important in meeting current production requirements. This equipment also allows the capture and reporting of test results, which are extremely important to the TQMS process of improving first-time quality. Unfortunately, the lack of serial tracking in the MATPGB system prevents the use of much of this data.

Even this automated system, however, cannot expand the test cell capacity to a sufficient degree. Although the UDOS model shows that the cells are only utilized an average of 28% of the available time, substantial queues exist at the cells. This appears to be caused by problems in obtaining small pieces of

equipment in the test cells. This is described in more detail in paragraphs 8.5.2.2 and 8.5.3.

8.5.1.4 Personnel

MATPGB has personnel assigned in five specific areas: disassembly, balancing, subassembly, final assembly, and test. Direct labor includes two WG-5 helpers, one WG-7 repairer, 41 WG-9 repairers, and 18 WG-10 mechanics. All workers are currently assigned to first shift. The UDOS model shows a utilization rate of less than 35% for all workers. MDMSC observations, however, did not indicate substantial worker idleness. The additional worker effort appears to have two causes: the almost neverending search for parts (not reflected in the model) and the use of "over-induction" to keep busy. The cause of both of these efforts, as well as a description of the overall effects, is included in paragraph 8.5.3. This situation occurs in both MATPSS and MATPSI and is described in their paragraphs as well.

The workers appear to be quite knowledgeable and experienced and displayed a strong desire to meet production goals. The importance of this attitude is discussed in paragraph 8.5.1.5. Most workers are trained to work in several areas and are "loaned" between different areas in the RCC. This is an excellent practice and helps maintain a stable and well-trained work force.

Only WG-10 mechanics can be assigned to conduct GTE test cell operations. The use of these experienced senior workers in such a critical area is commendable, but limits the ability of the test cells to meet surge requirements. This is discussed further in paragraphs 8.5.2.2 and 8.5.2.3.

Current shift schedules cause a severe limitation in production capacity and unnecessarily long flowtimes for those PCNs modeled. This causes an expensive increase in the current WIP levels and needlessly high inventory levels. This problem is discussed in more detail in paragraphs 8.5.2.2 and 8.5.3. MDMSC did not identify any other significant personnel-related problems in the MATPGB process.

8.5.1.5 Explanation of Current Success

MATPGB is currently meeting all production requirements. This success is due largely to two factors:

- The existence of a large, highly-experienced work force with low turnover rates.
- The existence of enormous stocks of end items and subassemblies in the form of WIP, kits in storage, and official and unofficial bench stock.

These factors are identical to those found in MATPSS and MATPSI, as described in paragraphs 8.6.1.4 and 8.7.1.4. The difficulties generated by a dependence on work force experience and high levels of inventory are described in great detail in paragraph 8.7.1.4. A recommended solution to those difficulties is offered in the focus study "Reduction of Parts Inventory..." in paragraph 8.5.4.

8.5.2 Statistical System Performance Measures

A joint MDMSC/SA-ALC team met 10-14 July 1989 to validate the UDOS 2.0 model for MATPGB. This was accomplished by comparing the simulated throughput and flow time for each PCN modeled to the actual throughput and flow times recorded in FY 88. Other factors, such as process flow, resource utilization, and location of queues were examined as well, in accordance with the Acceptance Test Procedure for UDOS 2.0, previously delivered by MDMSC. The details of this validation process can be found in the validation meeting minutes in Section 8.0 of the DDB for MATPGB.

After validation was complete, a brainstorming session was conducted with MDMSC and SA-ALC personnel to determine areas of interest for experimentation and to select factors and levels that could be tested to address those areas. The resulting four factors were fit to a Taguchi L_9 Orthogonal array during the brainstorming session, and three test levels were selected for each. A copy of this array, showing the factors and levels selected, is shown in Table 8.5.2-1. The use of this array reduced the number of experimental model runs from 81 to nine.

MATPGB $L_9(3^4)$ TAGUCHI ORTHOGONAL ARRAY

TABLE 8.5.2-1

NORMAL WORKLOAD

EXP #	QTRS RUN	A TEST CAPACITY	B BALANCER TRAINING	C INDUCTION SCHEDULE	D TEST REJECTS
1	4	AS-IS	AS-IS	RANDOM FULL SHOP	10% (AS-IS)
2	2	AS-IS	+ 3 TRAINED 100%	LEVEL	0 %
3	2	AS-IS	+ 3 TRAINED 50%	RANDOM EMPTY SHOP	5 %
4	2	3 SHIFTS 7 DAYS/WEEK	AS-IS	LEVEL	5 %
5	2	3 SHIFTS 7 DAYS/WEEK	+ 3 TRAINED 100%	RANDOM EMPTY SHOP	10% (AS-IS)
6	2	3 SHIFTS 7 DAYS/WEEK	+ 3 TRAINED 50%	RANDOM FULL SHOP	0 %
7	2	LEVEL 2 + 2 STANDS	AS-IS	RANDOM EMPTY SHOP	0 %
8	2	LEVEL 2 + 2 STANDS	+ 3 TRAINED 100%	RANDOM FULL SHOP	5 %
9	2	LEVEL 2 + 2 STANDS	+ 3 TRAINED 50%	LEVEL	10% (AS-IS)

SURGE WORKLOAD

SG1	2	3 SHIFT, 7 DAY + 2 STANDS	+ 3 TRAINED 100%	LEVEL	0 %
SG2	2	3 SHIFT, 7 DAYS + 2 STANDS	+ 3 TRAINED 100%	RANDOM EMPTY SHOP	0 %
SG3	2	AS-IS	AS-IS	RANDOM FULL SHOP	10% (AS-IS)

LSC-20558

The experimental runs described in Table 8.5.2-1 were conducted on the UDOS 2.0 model for MATPGB, using FY 88 induction rates for all PCNs modeled. Certain configurations were also tested at war time surge workload levels based on surge figures provided by HQ AFLC. Paragraphs 8.5.2.1 through 8.5.2.4 summarize the conduct and findings of these experiments. The detailed analysis and findings by PCN are provided in Section 10 of the MATPGB DDB.

8.5.2.1 Statistical Analysis of Current Conditions

The current configuration of MATPGB produces an average throughput (number of parts out/number of parts in x 100) of 104% when modeled on UDOS 2.0 (see Table 8.5.2-2 Experiment #1). This throughput figure indicates that the RCC has sufficient production capacity to meet current workloads. No PCN deviates significantly from this average.

Equipment utilization is generally low, with most fixtures used between 1-30%. Only the F-22 LB tester (63%) and the P-33 work stand (67%) are used more than 1/2 the available time. This low utilization rate does not indicate excess equipment. It is quite common in RCCs where a large number of very specialized pieces of equipment are used. In MATPGB the large number of special hand tools modeled (most with utilization rates of 1-4%) drives the extremely low average utilization rates.

The test cells described in paragraph 8.5.1.3 are used an average of 28%. This low utilization rate, coupled with the relatively minor impact achieved by adding test cells in experimentation (paragraph 8.5.2.2), makes it very difficult to justify additional test cell equipment purchases.

Manpower utilization for the primary skill areas (mechanics and test/inspectors) was 34% and 15% respectively. This utilization does not include time spent on indirect activities (clean-up, ordering parts, etc), but does include average time lost to vacation, sick leave, training, and the 20% workload that is unmodeled. While these utilization rates are lower than those found in many RCCs,

MATPGB $L_9(3^4)$ TAGUCHI ORTHOGONAL ARRAY THROUGHPUT EXPERIMENTAL RESULTS - FY 88

TABLE 8.5.2-2

EXP #	QTRS RUN	A TEST CAPACITY	B BALANCER TRAINING	C INDUCTION SCHEDULE	D TEST REJECTS	NORMAL WORKLOAD		
						AVG	BEST	WORST
1	4	AS-IS	AS-IS	RANDOM FULL SHOP	10% (AS-IS)	104%	13081A 107%	13095A 101%
2	2	AS-IS	+ 3 TRAINED 100%	LEVEL	0 %	94%	13095A 97%	13081A 87%
3	2	AS-IS	+ 3 TRAINED 50%	RANDOM EMPTY SHOP	5 %	95%	13095A 96%	13081A 90%
4	2	3 SHIFTS 7 DAYS/WEEK	AS-IS	LEVEL	5 %	96%	13095A 97%	13081A 90%
5	2	3 SHIFTS 7 DAYS/WEEK	+ 3 TRAINED 100%	RANDOM EMPTY SHOP	10% (AS-IS)	93%	13095A 96%	13081A 88%
6	2	3 SHIFTS 7 DAYS/WEEK	+ 3 TRAINED 50%	RANDOM FULL SHOP	0 %	96%	13094A 98%	13081A 90%
7	2	LEVEL 2 + 2 STANDS	AS-IS	RANDOM EMPTY SHOP	0 %	94%	13095A 97%	13081A 88%
8	2	LEVEL 2 + 2 STANDS	+ 3 TRAINED 100%	RANDOM FULL SHOP	5 %	95%	13094A 97%	13081A 90%
9	2	LEVEL 2 + 2 STANDS	+ 3 TRAINED 50%	LEVEL	10% (AS-IS)	95%	13094A 97%	13081A 90%

						SURGE WORKLOAD		
SG1	2	3 SHIFT, 7 DAYS + 2 STANDS	+ 3 TRAINED 100%	LEVEL	0 %	78%	13095A 100%	13081A 37%
SG2	2	3 SHIFT, 7 DAYS + 2 STANDS	+ 3 TRAINED 100%	RANDOM EMPTY SHOP	0 %	96%	13094A 100%	13081A 88%
SG3	2	AS-IS	AS-IS	RANDOM FULL SHOP	10% (AS-IS)	56%	13094A 87%	13081A 17%

LSC-20545

manpower is often a contributing factor to queues at various operations. This can be eliminated by better shift scheduling, as recommended in paragraph 8.5.2.4.

While test capacity does cause a bottleneck, existing capacity is sufficient to meet current production demands. Two of the PCNs modeled (13081A and 13094A) spend only 7.4% and 14% of their respective average flowtimes waiting. These parts appear to have relatively simple processes which are less affected by delays and bottlenecks. PCN 13095A spends 49% of its average flowtime waiting in queues. The most significant queues are in the areas of assembly--where it waits on subcomponents and floating stock, and test--where it waits on the test cells. These figures do not include delays caused by parts shortages or engineering/administrative delays.

The average WIP consists of 26.5 end items, with a total acquisition cost of $1,923,255. The highest WIP level achieved during the simulation run was 59 end items, at a combined acquisition cost of $4,323,385. This does not include uninducted kits in the MATSS parts pool or items delayed in MATPGB awaiting parts or engineering assistance. It does include parts in various back shops that are scheduled to return to MATPGB.

8.5.2.2 Experimental Results Under Normal Workload

Factor A - Increased test capacity, produced significant improvements for all PCNs modeled. Placing the current operations on three eight-hour shifts, seven days per week produced an average 36% reduction in overall flowtime. PCN 13095A was the most affected PCN at 58%. Adding two additional test cells produced an average additional 1% reduction in flowtime. No significant (5% or greater) effects on throughput were observed. WIP inventory levels dropped in proportion to flowtime decreases. These effects clearly indicate that the test capacity is the significant bottleneck in MATPGB process flows. This is substantiated by surge experiments in paragraph 8.5.2.3.

Factor B - Three additional workers in the balancing area produced less than 1% improvement in the flowtimes or throughputs of 13081A and 13094A. The

condition of training (trained vs. untrained) in the new workers had no impact. This area does not appear to be a bottleneck in the flow of these PCNs. PCN 13095A, however, experienced a 19% decrease in flowtime when three untrained balancers (modeled at an average of 1/2 the productivity of a trained worker) were added to the RCC. This PCN experienced an additional 3% decrease in flowtime when the workers became fully trained. This effect is discussed in greater detail in paragraph 8.5.2.4.

Factor C - Adjustments in the induction schedule produced less than 1% change in the flowtimes or throughput of 13081A and 13094A. The flow of these PCNs appears to be significantly constrained by the test capacity and unaffected by any other process improvement at current production levels. PCN 13095A again moved against the trend in the RCC by showing a 22% decrease in flowtime when inductions were leveled (maximum WIP limits set to control the number of parts in the RCC) to simulate a JIT flow. Inducting parts into an empty shop (elimination of the model warm-up period) produced a 20% decrease in the flowtime of 13095A. See paragraph 8.5.2.4 for additional analysis.

Factor D - A reduction of the test rejection rate produced less than 5% average improvement in the flowtimes and throughputs of 13081A and 13094A. Reducing test rejections from 10% to 5% produced a 21% decrease in the flowtime for 13095A. A reduction from 5%-0 produced an additional 5% decrease in flowtime. No significant effects were observed for throughput for any PCN.

The best combination of factors is:

Factor	Level
A	3
B	2
C	2
D	2

8.5.2.3 Experimentation Under Surge Conditions

Three experimental runs were conducted under surge workloads. These workloads were calculated using figures provided by HQ AFLC. Given the insignificant responses from factors B-D, MDMSC did not elect to use an orthogonal array.

The current RCC configuration was tested under surge conditions (surge run #3). The total productive capacity of MATPGB was insufficient to meet surge requirements, producing an average throughput of only 56%. The single most critical bottleneck under these conditions was the test cell area.

The best configuration of Taguchi factors and levels, as identified in paragraph 8.5.2.2, was tested in surge run #1. This configuration alleviated the test cell bottleneck, but throughput only increased to 78%. The new constraint was the maximum WIP levels placed to establish JIT flows. These levels were adequate for production at peacetime levels but insufficient for surge. This RCC, in its current condition, is completely dependent on large inventories of WIP to meet production requirements.

A third surge run (SG2) was conducted at the Taguchi "best" configuration, with maximum WIP limits removed. This run produced an average 96% throughput under wartime surge conditions. WIP inventory levels increased approximately 60%. PCN 13081A was the most difficult part to produce (86% throughput). The primary reason for all throughputs less than 100% appeared to be a shortage of floating stock (spare subassemblies). Both 13081A and 13095A managed to completely exhaust their supplies of floating stock during the experimental run. This further supports the conclusion that this RCC is extremely dependent on high inventory levels to meet production requirements.

8.5.2.4 Conclusions and Recommendations

MDMSC concludes that MATPGB has sufficient manpower and equipment to meet both normal and wartime surge requirements. While test capacity is a constraint, this can be substantially alleviated by shift scheduling without adding new equipment or workers. The addition of two test cells produced only a very

small improvement. SA-ALC's current LIFT plan objective of building a new test facility is premature in light of the UDOS experimental results. The benefits may be more easily obtained through shift work than new construction and capital equipment purchase.

The experiments showed that the third engine (PCN 13095A) was significantly affected by all tested factors. This indicates that the production process (line) for this engine is not in balance, and that production must be supported by substantial buffer stock. Floating stock statistics collected during process characterization show this end item as having the highest stock consumption of the three characterized. Increases in the capacity of any point in the process for this part will only increase the process ability to convert inventory into WIP at the next operation. A solution to this problem is described in the focus study recommended in paragraph 8.5.4

Based on UDOS experimentation results, MDMSC offers the following recommendations:

- MATPGB management should immediately consider shift work for all BK-10 production test workers. If this change produces sufficient process improvements, MATPGB should re-examine the request for a new test facility.

- MATPGB should procure an additional 60% increase in stocks of GTE kits and subassemblies, as well as construct an additional 20,000 square foot facility for storage of same. If this action is deemed too expensive, MATPGB management should consider implementing the focus study recommendation "Reduction of Parts Inventory..." found in paragraph 8.5.4.

8.5.3 Description of Process Problems

The most significant problem in MATPGB is the severely unbalanced flow and the huge demand for inventory that this produces. The result is severe over-induction of work and huge levels of inventory clogging the shop floor. These inventory levels obscure real process problems and deny management the

visibility they need to adequately manage the production process. MDMSC was unable to find anyone at SA-ALC who knew the condition of the kits in the MATPSS parts pool, the number of GTEs awaiting parts, or the volume of floating stock (official and otherwise) in the RCC. While everyone complained of parts shortages, no one had any idea how bad the problem actually was. This situation is virtually identical to that found in MATPSS, and is described in much greater depth in paragraph 8.7.3.

A second process problem was identified in the test cell area. MATPGB currently reports a 10-15% reject rate on GTEs tested. This rejection results in a return of the item to disassembly and a performance of 100% rework. Using FY88 induction figures and repair costs provided by SA-ALC, a 15% rejection rate for those PCNs modeled in MATPGB alone generates an average annual cost of $2.3 million. (See section 13 of the DDB for additional data.) The current practice in MATPGB is to induct and build an additional 15% supply of GTEs to "cover" for test rejections. This activity serves to mask the cost of the test rejection problem and significantly contributes to the problem of over-induction/excessive inventory.

This problem is exacerbated by MATPGB's policy of removing serial plates from GTEs during the repair process. This prevents the engineers supporting MATPGB from gaining any real data from the expensive automated test cell system they have installed. In MDMSC's experience, this practice is absolutely unacceptable in the commercial aircraft manufacture or repair industries. Federal Aviation Regulation (FAR) parts 121.369(c)-Manual Requirements, and 121.373(a)-Continuing Analysis and Surveillance, require adequate systems of failure tracking/analysis and reporting of such. This data is vital, for aircraft and major ground support equipment items, to ensure adequate data is available to evaluate process quality and to determine contributing causes in aircraft mishap investigations. While the Air Force is not managed under civilian FARs, they should maintain maintenance quality standards at least as stringent as their civilian counterparts.

Given the practice of overinducting to account for rejections, rejected GTEs are disassembled and returned to the MATSS parts pool, rather than being reassembled and retested. MDMSC suspects that a small percentage of the GTE population, or a small percentage of floating subassemblies, are causing 80% of the rejections. This cannot be confirmed (or corrected) without end-to-end serial number tracking of every GTE. MDMSC recommends that such tracking be implemented <u>immediately</u>.

MDMSC further recommends that the process engineers assigned to support MATPGB take personal responsibility for evaluating the cause of <u>each</u> failure and recommending process changes to prevent reoccurrence. This program should be undertaken with the full participation of the MATPGB work force, as part of a QP4 process improvement team. The use of Taguchi experimental arrays and the quality/loss function will help measure and control the actual costs of this effort. Because this is an opportunity for a classic application of the TQM process improvement method, and requires intimate <u>continuous</u> involvement with the process under study, MDMSC does not recommend this effort as a focus study. It is important that all levels of production, management, and engineering in SA-ALC feel personally responsible for the success of the effort. If this effort were undertaken in an MDMSC facility, a reasonable goal would be the elimination of 99% of all test rejections in the first year.

8.5.4 <u>Recommended Focus Study: "Reduction of Parts Inventory and Improvement in Flow Time/Throughput"</u>

The objective of this focus study is to design a balanced repair processing line, where delays are minimized and inventory costs are reduced by 50-70%. It will address the flow through MATPGB, MATPSI, and MATPSS. The goals of the design process will be to:

- Minimize inventory costs (including storage/floorspace), in-process queuing, and part flow time.
- Maximize the total throughput (under peacetime and wartime conditions) and increase the "robustness" of the RCCs by reducing their sensitivity to problems such as parts shortages or machine failures.

- Maximize the level of process feedback available to support continuous QP4 process improvements.
- Maximize the availability of end item spares in forward supply points to increase USAF combat readiness.
- Minimize the cost of implementing the design by utilizing existing resources to the greatest extent possible.

A list of activities that MDMSC proposes to perform in this focus study is detailed in Table 8.5.4-1. A focus study criteria checklist is shown in Table 8.5.4-2. The proposed deliverable items under this focus study are:

- A final report including the detailed design of the recommended structure for these RCCs, an inventory management plan, an analysis of the results of the UDOS 2.0 experimentation, a recommended layout diagram, and a projection of cost and productivity improvements.
- A copy (in electronic format) of the As-Is UDOS 2.0 model, updated to include any PCNs added since Task Order 1.
- A copy (in electronic format) of the UDOS 2.0 model developed to model the proposed structure of these RCCs.
- An assessment of the proposed structure's performance under various workload conditions, including wartime surge.
- Recommendations for the procurement of additional capital equipment (if required) with associated cost/benefit analysis.
- An MDMSC implementation plan proposal.
- An executive summary report describing the extent to which the focus study objective and goals were met.
- Five monthly status reports describing the activities and accomplishments of MDMSC in conducting this study.
- Any software products developed or purchased by MDMSC specifically for use on this focus study.

8.5.4.1 Rationale Leading to Change

The flow through MATPGB, PSS, and PSI is severely unbalanced, without adequate scheduling supervision, resulting in over-induction of items, swamping of bottlenecks, wasteful "in-process" queuing of parts and long flow times. As in

PROJECTED MDMSC ACTIVITIES

TABLE 8.5.4-1

STEP	ACTIVITY
1	Survey all PCNs in each RCC to identify any which should be added to the current UDOS baseline. This will include assessment by process and cost.
2	Establish a part/flow tracking system to identify flows in/out of the RCCs and across critical operations.
3	Use the updated UDOS models to assess total RCC capacity.
4	Use supply data to determine total customer demand (based on field order rates and PDM schedules) for each PCN.
5	Using IE standard ergonomic data and flow/balance management software, MDMSC will redesign each operation and re-layout the flow through these operations for each PCN.
6	The structure designed in step 5 will be modeled on the UDOS 2.0 software and studied under simulation. Changes made as required.
7	The location and volume of inventory stocks will be re-evaluated and a plan developed to support the process designed in steps 5/6. Excess inventory will be identified.
8	An induction schedule/scheduling algorithm will be developed that insure a "drum-buffer-rope" minimum inventory, maximum capacity work flow.
9	All reports and software deliverables will be prepared and delivered per contract requirements.

MATPGB FOCUS STUDY CRITERIA CHECKLIST

TABLE 8.5.4-2 (SHEET 1 OF 2)

AREA OF ANALYSIS	ACTIVITY (WHAT & HOW)
Process/Material Flow	Reviewed and modified as required.
Equipment/Work Place Layout	Reviewed and modified as required.
Facility Requirements	Reviewed and modified as required.
Labor Standards	No MDMSC activities regarding labor standards.
Manpower	Reviewed and modified as required.
Task Assignments	Reviewed and modified as required.
Material Requirements	Identify recommended stock to insure a balanced flow. The location and volume of inventory will be re-evaluated and a plan developed. Excess inventory will be identified.
Scrap Rates	Not directly affected.

LSC-20659

MATPGB FOCUS STUDY CRITERIA CHECKLIST

TABLE 8.5.4-2 (SHEET 2 OF 2)

AREA OF ANALYSIS	ACTIVITY (WHAT & HOW)
Material Handling & Storage Methods	Reviewed and modified as required.
Inspection Techniques	No direct effects.
Equipment/Tools/Fixtures	Reviewed and modified as required.
Process Delays	Revise process flow to reduce and or eliminate potential delays where possible.
Part Identification	No direct effects.
Quality	Visibility of process quality problems will be increased.
Personnel Safety	No direct effects.
Environmental Assessments	No direct effects.

LSC-20659

most commercial operations with these problems, these RCCs protect themselves by maintaining large stocks of buffer inventory, in the form of kits (used for cannibalization), floating stock and unofficial "bench stocks" of various spares. The sheer volume of this inventory masks the extent/existence of many of the problems that the inventory was procured to alleviate (i.e., shortages of critical subassemblies, poor quality/unresponsive deliveries from vendors, manpower shortages, or machine/process bottlenecks). MAT management cannot identify or evaluate problems in the production process because feedback on the problems is buried under a sea of expensive inventory. The QP4 process, which depends on this feedback to improve the production process, cannot be successfully implemented under the current system.

8.5.4.2 Potential Cost Benefits

The UDOS 2.0 models for MATPGB, PSS, and PSI indicate a WIP inventory worth over $28 million ($24 million is in MATPSI) based on end item acquisition costs. In addition, MDMSC engineers estimate another $20 million worth of inventory is stored in MATPSS parts pools in Building 329. (No accurate SA-ALC estimate was available.) MDMSC estimates, based on model experimentation, indicate that a minimum 50-70% reduction in inventory can be achieved, resulting in a cost avoidance of $24-$34 million. While no cost data was available on floating stocks of subassemblies, a similar reduction in volume is projected.

The elimination/return to supply of this inventory will free approximately 16,000-22,000 square feet of floorspace currently used in Building 329 for inventory storage.

MDMSC expects to identify potential reductions in manpower and fixturing as a result of the restructuring, but cannot estimate the value at this point. A primary goal of the study will involve the reassignment of resources, rather than the recommendation to procure new resources. This approach will minimize the SA-ALC capital costs to implement the resulting plan. As model

experimentation for these RCCs generally shows the total resources to be adequate, MDMSC expects significant success in minimizing implementation costs.

8.5.4.3 Risk Assessment of Achieving Study Goals

The proposed flow designs and scheduling techniques are used extensively in Japan, and increasingly in American commercial industry, with reliable success. Reductions in inventory, and improvements in process quality at the Harley-Davidson Corp. plant (which undertook a similar, though more extensive, restructuring in 1986) were so dramatic that President Ronald Reagan called them an example for American industry. In addition, the experiments conducted on the UDOS 2.0 models for these RCCs give strong indications that these proposed techniques will work at SA-ALC. MDMSC believes the risk of not achieving the goals of this study to be extremely low.

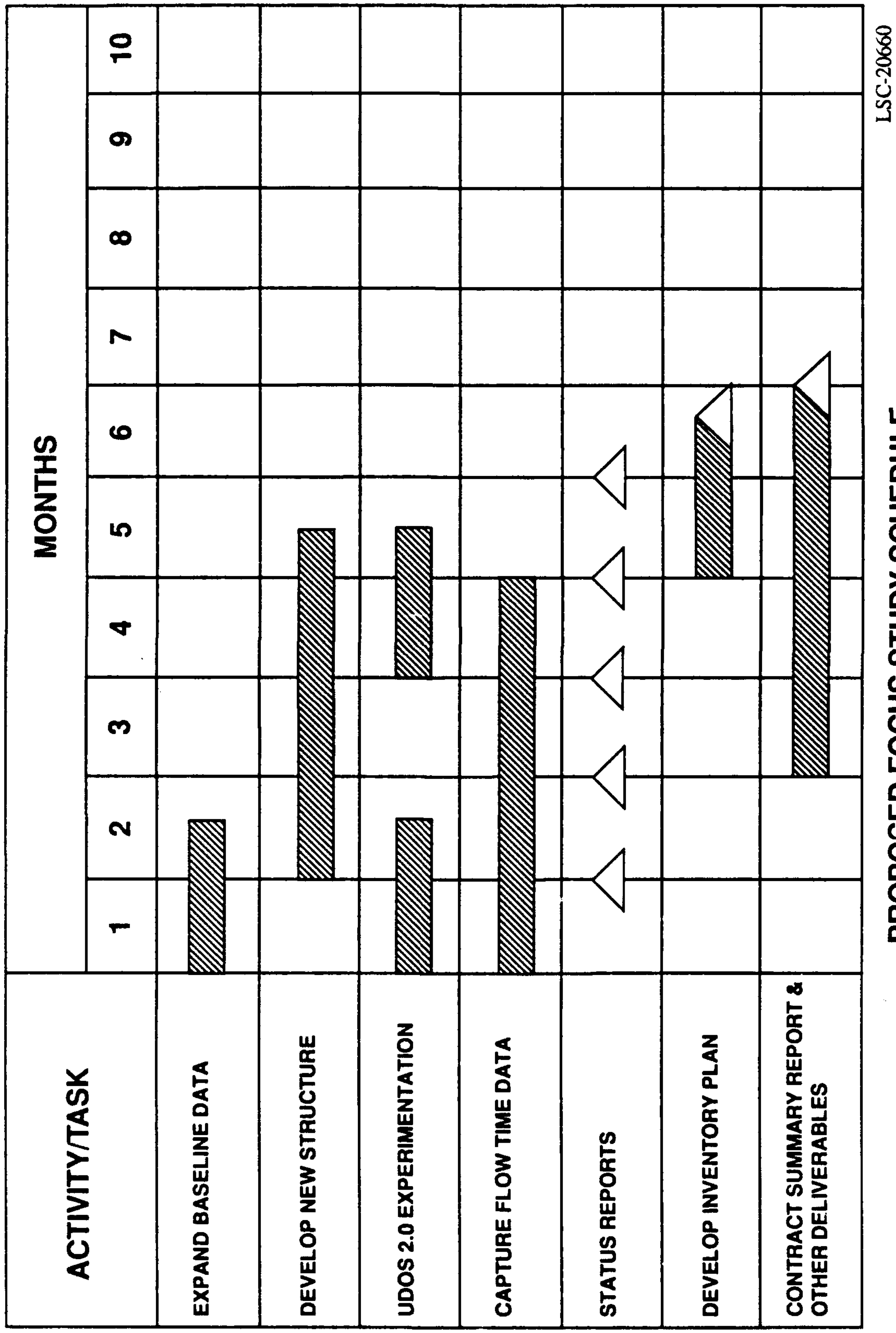
UDOS 2.0 model assessments of each RCC indicate that they generally have sufficient resources to meet production requirements (even at surge levels), if the resources are properly laid-out and scheduled. MDMSC believes this indicates that implementation costs will be very small. The primary source of risk in implementation is that actual required repair rates (based on PDM schedules and field failure rates) may greatly exceed the current negotiated induction rate for these RCCs. If this proves to be true (considered unlikely), it may force MDMSC to recommend SA-ALC spend considerable capital sums in the implementation of this plan.

8.5.4.4 Duration and Level of Effort

The program schedule is presented in Figure 8.5.4-1. The total duration of the study will be six months from date of contract turn-on. The level of effort will be:

Two MDMSC industrial engineers full time - 1968 manhours
One MDMSC simulation expert 1/2 time - 492 manhours
One MDMSC engineering supervisor 1/2 time - 492 manhours

Five hundred to one thousand dollars worth of PCN based IE software will be procured. This software will be the property of the U.S. government at contract completion.



PROPOSED FOCUS STUDY SCHEDULE
FIGURE 8.5.4.1

The total Rough Order of Magnitude (ROM) cost for this effort is estimated at $380,000.00. This includes manhours, computer processing costs, travel, clerical support, software purchase, and MDMSC fee.

8.5.5 Other Observations

- Gas Turbine Engine
  - Current Condition: During the assembly and test process of the GTE, the GTE is assembled on a wheeled positioning stand. It is then placed on a skidded transport stand to move it from assembly to test area by forklift. The GTE is then removed from the transport skid and placed on a wheeled test stand. After testing is completed the GTE is removed from test stand and placed onto a shipping stand.
  - MDMSC Recommendation: Replace currently used stands with a universal assembly and test stand, thus eliminate loading and unloading of the GTE.
- Gas Turbine Engine Transportation
  - Current Condition: Gas turbine engines are moved by forklift from Building 329 final assembly area to testing in Building 340. Some forklifts have pneumatic tires; others have hard rubber tires. The GTEs are transported over some rough road between the buildings. Forklifts with hard tires sustain greater jarring and shock which may cause damage to carbon seals on some engines. When tested, the engine could fail and repeat overhaul would then be required.
  - MDMSC Recommendation: Move GTEs between buildings via overhead conveyor (focus study for feasibility required) or, at a minimum, on a forklift with pneumatic tires. A better choice would be to place the GTE on a cushioned, pneumatic-tired wagon and tow it to Building 340 with a tug.
- Tool Callout
  - Current Condition: Tool callout on Work Procedure (WP-009) is not correct for actual usage for operation number 150, WCD TG989F; some tools are not identified and some tools are not required.

- MDMSC Recommendation: Correct callout for WP-009 for tools actually required to do this operation. Assign tools a number code for identification and add to WP-009 list.

- <u>Compressor Buildup Technical Order (Technical Order)</u>
  - Current Condition: Technical Order Number 15, page 27, line E-6: mechanic is not able to follow this requirement because "matched parts" do not match.
  - MDMSC Recommendation: Remove this requirement from the Technical Order or supply truly matched parts.
- <u>Standardizing Work Control Documents</u>
  - Current Condition: No apparent standard exists or is used to ensure that WCDs are written using a consistent format and content. No standard format is used for notes and supplementary cautions, warnings or other information. Since many different planners write these documents, different sequences and process steps result for very similar parts and assemblies. Also, there is a risk of omitting vital steps or calling out incorrect equipment procedures, which results in incomplete or confusing WCDs.
  - MDMSC Recommendation: Develop standards for writing WCDs. Make it mandatory that engineers and planners use the standard procedures. Ensure that WCD writers go to the shop floor before, during and after writing to observe the "real world" equipment and processes.
- <u>Improve Accuracy and Availability of Historical Records</u>
  - Current Condition: Historical copies of WCDs are only retained for six months before being discarded. The WCDs are stored in boxes in out-of-the-way areas of the facility. Some WCDs are not retained at all for certain operations. Instances of "gang stamping," i.e., stamping off the entire WCD at the same time, have been noted.

    A six-month time period does not provide a sufficient basis to observe long-term trends. Gang stamping results in unreliable data for determining flow data. WCDs cannot be used to evaluate standards

for comparison purposes. Some WCDs have become oil and water stained or are otherwise unreadable.

- MDMSC Recommendation: Retrain the personnel who stamp off documents in the proper procedure and enforce with periodic checks by supervision. Set up a system to systematically file the records for each end item together. Retain the paper copies for at least one year to enhance the ability to do trend analysis. Consider the possibility of microficheing the older, historical data if any long-term trend analysis is to be performed. In, out dates by end items can be put into a database to provide a means of tracking flowtimes. This program can be tied in with the Direct Material Management System (DMMS) for overall process/production control.

8.6 MATPSI ANALYSIS AND FOCUS STUDY RECOMMENDATIONS

MATPSI disassembles, cleans, and inspects Jet Fuel Starters (JFS), Accessory Drive Gearboxes (ADG), Central Gear Boxes (CGB), and Aircraft Mounted Accessory Drives (AMAD). MATPSI also performs cleaning and inspection operations on Gas Turbine Engines (GTE) forwarded to it from MATPGB and other accessories for various aircraft.

The current processes, facilities, equipment, and manpower found in this RCC are described in paragraphs 8.6.1.1 through 8.6.1.4. A description of the statistical experimentation is described in 8.6.2. Significant problems found in the current process are detailed in paragraph 8.6.3 while 8.6.4 describes additional observation of improvement opportunities.

8.6.1 <u>Description of Current Operation</u>

This paragraph summarizes the engineering assessment of the As-Is conditions within MATPSI, including processes, facilities, equipment, and personnel. Where appropriate, it includes MDMSC recommendations for changes and identification for strong and weak points in the RCC's operation.

8.6.1.1 Current Processes

The primary workload of MATPSI consists of Management of Items Subject to Repair (MISTR). The 80/20 workload analysis for this RCC was created to characterize the processed parts which represent the total RCC workload. As MATPSI, PGB, and PSS were studied together, the MATPSI workload was developed using PCNs that were common to all three. This produced a UDOS model that provided maximum utility and was acceptable to the TI-ES validation team described in paragraph 8.6.2. MATPSI has three distinct functions: disassembly of certain aircraft starters and F-15 and F-16 end items, cleaning of parts from these end items after disassembly (plus MATPGB parts from GTE), and inspection of the cleaned parts. Some parts are sent directly to the parts pool without inspection (nuts, bolts, spacers, etc.). Some are sent through Fluorescent Penetrant Inspection (FPI) and/or Magnetic Particle Inspection (MPI) prior to visual and dimensional inspection, while others go directly from

cleaning to inspection. A typical process flow for these items is shown in Figure 8.6.1-1.

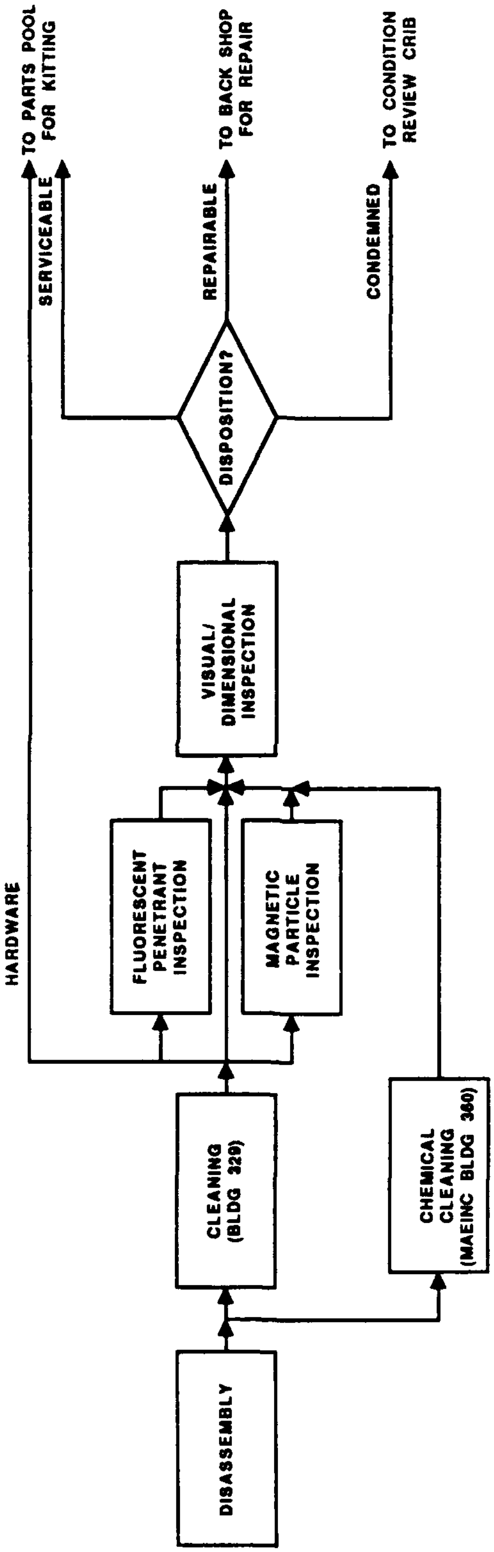
These items are received from MATSS scheduling in an end-item form. They are disassembled, cleaned, and inspected by MATPSI mechanics. A mounting stand or fixture is used for disassembly of the items, which are then sorted and sent to cleaning, inspection, and parts pool.

Parts requiring cleaning are brought into the cleaning area in plastic baskets and stacked on the floor. Each basket contains parts of a specific metal type, which dictates the cleaning process to be used. WCDs are not used for the bulk of items requiring cleaning. WCDs are assigned to each item when it passes through the FPI station after cleaning so the document can receive the inspector's stamp. Parts not passing through FPI receive their WCD when they enter the inspection room to be given visual and dimensional inspections. Some hardware parts, such as nuts and bolts, go straight to the parts pool after disassembly and cleaning. Some of the WCDs assigned to the parts in the inspection room direct the part to cleaning after return from a back shop.

The inspection function has three inspection lines based on the three basic types of items inspected: GTEs, Aircraft Starters, and F-15/16 Jet Fuel Starters. Parts are delivered to the inspection room by two methods; (1) by a double-decked roller conveyor system which enters the room from the cleaning and FPI work areas, and (2) by four-wheeled carts manually pushed into the room for those parts assigned a critical priority. The conveyor branches into three lines (corresponding to the above items) inside the room with each conveyor passing through the middle of each inspection line, thereby creating a total of six inspection areas. Each of the six inspection areas has six to eight inspection stations. After inspection, parts leave the room via the upper roller conveyor line or the four-wheel carts.

8.6.1.2 Facilities

MATPSI's three functions occupy space in Building 329. Over 60 years old, Building 329 is in good condition. Freestanding air-conditioned modules have



LSC-20351

SA-ALC MATPSI PROCESS FLOW CHART
FIGURE 8.6.1-1

been constructed within the building for operations such as offices, disassembly, assembly, and inspection of various parts. In these modules, working conditions are comfortable for all functions of MATPSI. Only the parts cleaning function is not enclosed in a module.

The disassembly function is located in a module constructed inside the northeast corner of Building 329. The area is now being remodeled to install a basket conveyor to move disassembled parts from individual work stations to the cleaning area which is located just outside the module. When the renovation is complete, there will be over 30 disassembly work stations.

The cleaning function is located in the northeast corner of Building 329. The physical area is approximately 18 feet wide by 300 feet in length and is not air-conditioned. Working conditions are poorer than the rest of MATPSI. Air conditioning is impractical given the ventilation requirements of tanks containing high temperature caustic liquids. Within the next few months, the cleaning function will be relocated within Building 329 and completely redone. Some of the existing area will be utilized, but new equipment will be installed and a new floor layout will be implemented. MDMSC was unable to obtain any layout drawings or other documentation describing the new cleaning facility, and thus, cannot evaluate the effectiveness of the change. The current cleaning operation is a process bottleneck, however, and is discussed in more detail in paragraph 8.6.3.

The inspection function is located in a freestanding module located inside the north end of Building 329. The module is air-conditioned with temperature and humidity maintained at precisely 72°F and 68% respectively, to prevent calibration variances in the precision dimensional measurement equipment used in the shop.

8.6.1.3 Equipment

The equipment used in the disassembly process consists of various locally-manufactured holding fixtures and a broad assortment of common and specialized hand tools. Some pneumatically-driven hand tools are used. A

typical work station in disassembly consists of a workbench, a mounting stand or fixture for the item to be disassembled, and a nearby cabinet for stored special tools.

Cleaning equipment consists of grit blasters and tanks containing various liquids. The tanks have cleaning and degreasing solvents, decarbonizing and hot water rinses and washes. Chemicals used for cleaning include hydroxamine (carbon remover) phosphoric acid, hot water rinse, and perchlorethylene. PD-680 is used as a degreaser and drying agent. No hazard warning signs were observed in the cleaning area.

Four of the grit blasters are recent purchases and are having maintenance difficulties. Apparently they were not made for glass bead operations, and they are failing. A change to walnut shell abrasive has been implemented since initial process characterization.

The first few stations on each inspection line have the Automated Prompting Inspection System (APIS) and the MICRO-4, both computer driven dimensional measurement machines. The remaining inspection stations are manual dimensional measurement stations. While the inspection equipment appears to be in good repair, and the technology level is equal to that used in many commercial inspection facilities, MDMSC suspects the existence of a process problem. GTEs show a high failure rate in final test for excessive vibration. This is an indicator of a possible balancing or geometric inspection problem. This situation is described in greater detail in paragraph 8.5.3.

MDMSC engineering assessment, as well as examination of the UDOS 2.0 equipment utilization rates, indicates that none of MATPSI tools or fixtures are significant bottlenecks in the flow of parts through the RCC. MDMSC concludes that the current quantities of hand tools, fixtures, and equipment are adequate and that an addition would not produce any significant improvement in current MATPSI operations.

8.6.1.4 Personnel

MATPSI currently employs 82 production workers with various skill levels and specialities. The experience level of this work force is generally higher in the inspection area than in the disassembly and cleaning areas. The knowledge and experience of the entire work force is equal or higher than that found in many commercial operations and is a key factor in the successful operation of MATPSI.

There are 48 people assigned to MATPSI inspection. The lowest Wage Grade permitted for an individual to be a certified inspector is WG-09. Those in a lower grade are assigned to various inspection tasks; however, a certified inspector must check their work and "sign off" the completed WCD. The inspection function has a shortage of certified inspectors. This shortage has developed over several years as a result of hiring freezes implemented to save operating and maintenance funds. Personnel have been "loaned" to this function from other RCCs. Approximately one third of the assigned personnel are "loaners." These loaned personnel receive insufficient on-the-job training and because of their job classification policy they cannot receive certification as qualified inspectors. This situation <u>may</u> be a contributing factor to the GTE process problem described in paragraph 8.5.3. Without the results of the study described in that paragraph, MDMSC cannot provide firm recommendations.

8.6.1.5 Explanation of Current Success

MATPSI is currently meeting all production requirements. This success is due largely to two factors:

- The existence of a large, highly-skilled work force with low turnover.
- The existence of enormous stocks of subassemblies, in the form of WIP, kits in storage, and official and unofficial bench stocks.

The importance of these strengths, and their effects on the production process, are identical to those described in MATPSS and MATPGB. Further description of this can be found in paragraphs 8.5.1.5 and 8.7.1.5.

8.6.2 Statistical System Performance Measures

A joint MDMSC/SA-ALC team met 10-14 July 1989 to validate the UDOS 2.0 model for MATPSI. This was accomplished by comparing the simulated throughput and flow time for each PCN modeled to the estimated throughput and flow times provided by MATPSI supervision. Other factors, such as process flow, resource utilization, and location of queues were examined as well, in accordance with the Acceptance Test Procedure for UDOS 2.0, previously delivered by MDMSC. The details of this validation process can be found in the validation meeting minutes and in Section 8.0 Validation of the DDB for MATPSI.

After validation was complete, a brainstorming session was conducted with MDMSC and SA-ALC personnel to determine areas of interest for experimentation and to select factors and levels that could be tested to address those areas. The resulting four factors were fit to a Taguchi L_9 Orthogonal array during the brainstorming session, and three test levels were selected for each. A copy of this array, showing the factors and levels selected, is shown in Table 8.6.2-1. The use of this array reduced the number of experimental model runs from 81 to nine.

The experimental runs described in Table 8.6.2-2 were conducted on the UDOS 2.0 model for MATPSI, using FY 88 induction rates for all PCNs modeled. Certain configurations were also tested at surge workload levels based on surge figures provided by HQ AFLC. Paragraphs 8.6.2.1 through 8.6.2.4 summarize the conduct and findings of these experiments. The detailed analysis and findings by PCN are provided in Section 10 of the MATPSI DDB.

8.6.2.1 Statistical Analysis of Current Conditions

The current configuration of MATPSI produces an average throughput (number of parts out/number of parts in x 100) of 88%. Throughputs for individual PCNs ranged from 08004A (104%) to 13081A (72%). The bulk of the throughputs less than 100% were caused by queues in the cleaning and dye penetrant (NDI) areas.

MATPSI $L_9(3^4)$ TAGUCHI ORTHOGONAL ARRAY
TABLE 8.6.2-1

EXP #	QTRS RUN	A WORK LOAD	B INSPECTION	C INDUCTIONS	D NOISE
1	4	FY88 BASELINE	AS-IS	RANDOM FULL SHOP	RANDOM SEED 1
2	2	FY88 BASELINE	+ 20 TRAINED	LEVEL	RANDOM SEED 2
3	4	FY88 BASELINE	+ 20 TRAINED	RANDOM EMPTY SHOP	RANDOM SEED 3
4	4	130% OF BASE	AS-IS	LEVEL	RANDOM SEED 3
5	4	130% OF BASE	+ 20 TRAINED	RANDOM EMPTY SHOP	RANDOM SEED 1
6	4	130% OF BASE	+ 20 TRAINED	RANDOM FULL SHOP	RANDOM SEED 2
7	4	SURGE	AS-IS	RANDOM EMPTY SHOP	RANDOM SEED 2
8	2	SURGE	+ 20 TRAINED	RANDOM FULL SHOP	RANDOM SEED 3
9	2	SURGE	+ 20 TRAINED	LEVEL	RANDOM SEED 1

LSC-20603

MATPSI $L_9(3^4)$ TAGUCHI ORTHOGONAL ARRAY THROUGHPUT EXPERIMENTAL RESULTS - FY 88

TABLE 8.6.2-2

EXP #	QTRS RUN	A WORK LOAD	B INSPECTION	C INDUCTIONS	D NOISE	NORMAL WORKLOAD		
						AVG	BEST	WORST
1	4	FY88 BASELINE	AS-IS	RANDOM FULL SHOP	RANDOM SEED 1	88%	08004A / 104%	13081A / 72%
2	2	FY88 BASELINE	+ 20 TRAINED	LEVEL	RANDOM SEED 2	44%	12712A / 96%	08007A / 19%
3	4	FY88 BASELINE	+ 20 TRAINED	RANDOM EMPTY SHOP	RANDOM SEED 3	75%	13095A / 92%	08006A / 39%
4	4	130% OF BASE	AS-IS	LEVEL	RANDOM SEED 3	34%	12712A / 69%	08005A / 15%
5	4	130% OF BASE	+ 20 TRAINED	RANDOM EMPTY SHOP	RANDOM SEED 1	52%	13081A / 83%	12712A / 8%
6	4	130% OF BASE	+ 20 TRAINED	RANDOM FULL SHOP	RANDOM SEED 2	58%	13081A / 99%	12712A / 5%
7	4	SURGE	AS-IS	RANDOM EMPTY SHOP	RANDOM SEED 2	46%	10598A / 70%	08006A / 5%
8	2	SURGE	+ 20 TRAINED	RANDOM FULL SHOP	RANDOM SEED 3	51%	04542A / 71%	08006A / 3%
9	2	SURGE	+ 20 TRAINED	LEVEL	RANDOM SEED 1	24%	12712A / 77%	08006A / 11%

NOTE: THE VARIANCE CAUSED BY CHANGING RANDOM SEEDS INVALIDATED THE RESPONSE FOR FACTOR B (FOR BOTH THROUGHPUT AND FLOWTIME) AND FOR FACTOR C (FOR FLOWTIME ONLY)

LSC-20587

Equipment utilization in the UDOS 2.0 simulation model was moderate, with critical pieces of equipment being used an average of 26% to 67%. The heaviest usage occurred in the cleaning, blasting, and NDI test equipment. Small queues routinely formed as parts waited for these parts.

Manpower throughout the RCC showed consistently high utilization, with rates of 54% to 98%. Cleaning and blasting personnel were easily the busiest workers in the simulation, with utilization rates of 96% to 98% under normal workloads. This utilization does not include time spent on indirect tasks (cleanup, ordering parts, etc.) but does include average time lost to vacations, sick leave, training, and the 20% workload not modeled. Under increased workloads, including wartime surge, these workers were busy 100% of the time and huge queues of parts formed awaiting their attention. The manpower in the cleaning, blasting, and NOI areas is the single most significant bottleneck in this RCC. This is discussed further in paragraph 8.6.3.

Queues exist throughout the RCC, but vary greatly by PCN. In the simulation, parts spent from 1% to 98% of their total flowtime waiting in queues.

The long waits common in MATPSI serve to boost the volume of WIP in the RCC. The average WIP level consists of 379.8 end items (in disassembled condition) with a total acquisition cost of $24,086,581. The volume of parts in this RCC is roughly ten times larger than that found in MATPSS or MATPGB. The maximum quantity of WIP occurring during a year's simulation was over twice the reported average. This situation is addressed in more detail in the focus study recommendation in paragraph 8.5.3.

8.6.2.2 Experimental Results Under Normal Workload

- FACTOR A - Increased workload was modeled in the array, to test the effects of various workloads on RCC throughput. The data from normal workloads is discussed in paragraph 8.6.2.1. Surge workloads are addressed in paragraph 8.6.2.3.

- FACTOR B - The addition of 20 inspectors produced no significant (greater than 5%) improvement in throughput or flowtime. This indicates that the inspection area is not a significant bottleneck under the current RCC configuration.
- FACTOR C - Leveled inductions (maximum WIP limits set) produced substantially improved flowtimes but severely decreased throughputs. This indicates that the current RCC is operating very near total capacity, and is experiencing some queueing. By limiting the amount of WIP, the model limits the volume of buffer inventories available and illustrates the RCC's current dependence on large volumes of inventory. This is further discussed in paragraphs 8.5.3, 8.5.4, and 8.6.3.
- FACTOR D - Changes in the random seed in UDOS operation, produced substantial, random shifts in the model's outputs. While these shifts are pseudo random and cannot be statistically related to RCC shop floor effects, they do serve to illustrate the volatility of the UDOS model for MATPSI. Caution must be used in generalizing from UDOS results to the MATPSI shop floor.

8.6.2.3 Experimental Results Under Surge Conditions

Surge workload levels were tested as part of the L_9 array used in the experimentation. As workload was increased to 130% of normal, throughput fell sharply and large queues began to form. The largest of these queues were in the area of cleaning and blasting with NDI running a close second. As workload was increased to surge levels, the situation simply became worse. Parts saturated every area in MATPSI and personnel, working at 100% of capacity, were unable to meet the production requirements.

8.6.2.4 Conclusions and Recommendations

MDMSC concludes that MATPSI, in its current configuration, is operating at very near total capacity. This RCC cannot meet surge requirements in its current configuration, without substantial numbers of additional personnel and cleaning equipment.

Based on the results of UDOS 2.0 experimentation, MDMSC offers the following recommendations to MATPSI management:

- Immediately consider shift work for all cleaning, blasting, and NDI personnel.
- Begin a cross-training program with other MATPSI employees to assist the current cleaning, blasting, and NDI crews.
- Consider the proposed focus study "Improvements in Parts Cleaning in Building 329" found in paragraph 8.6.4.
- Consider the focus study "Reduction of Parts Inventory..." found in paragraph 8.5.4.

8.6.3 Description of Process Problems

The most pressing process problem in MATPSI is the severely unbalanced line, with its dependence on large amounts of inventory. This problem, and the corollary effects it produces, is documented in considerable detail in paragraph 8.7.3. The MDMSC recommended solution involves the performance of the focus study "Reduction of Parts Inventory..." found in paragraph 8.5.4.

A second process problem in this RCC is the severe bottleneck in production at the cleaning and blasting operation. This bottleneck is significant at normal production levels and becomes unmanageable under wartime surge conditions. Cleaning or blasting equipment is kept much busier than any other equipment in the RCC, while cleaning and blasting personnel are working at near maximum capacity, and still queues form at this step.

Placing the workers on shifts, as recommended in paragraph 8.6.2.5, will provide some relief under normal workloads. The parts will flow more smoothly and equipment utilization will increase as the area begins to operate at lower batch levels (the current "batch" size of parts inducted for cleaning on a given shift is controlled by the number of workers available to induct). Still more improvement will occur if the operations feeding the cleaning and blasting steps are themselves operated on 24 hour shifts. This will produce a more balanced flow throughout and help buffer the "herbie" in the cleaning and blasting operation.

Unfortunately, the UDOS usage report for MATPSI indicates that, at higher than normal levels of production, the cleaning and blasting area lacks the physical capacity to meet produce demands. The operation cannot process enough parts, in its current configuration, regardless of the work schedules used. As equipment utilization is already approaching 100%, adding manpower through overtime or loan-ins will not correct the problem.

The only solution appears to be the redesign of the cleaning and blasting processes to increase capacity and reduce flowtime. To this end, MDMSC recommends that SA-ALC consider the focus study "Improvements in Parts Cleaning" described in paragraph 8.6.4. MDMSC is aware that MATPSI is already upgrading the cleaning line in MATPSI, but was unable to obtain enough data to evaluate the changes.

8.6.4 Recommended Focus Study: Improvements in Parts Cleaning in Building 329

The objective of this focus study is to redesign the cleaning and blasting operations in MATPSI to produce an increase *in total capacity* and a reduction in total flowtime.

The goals of this study will be to:

- Increase total capacity by a minimum of 100%.
- Decrease total operation flowtime by a minimum of 50%.
- Minimize the quantity of new capital equipment that must be recommended to meet the other study goals.
- Increase the quality of the cleaning and blasting work performed wherever technologically feasible.
- Maintain the new capacity within the existing floorspace allocation of the current.

The deliverables under this study will consist of:

- An enhanced UDOS 2.0 (or later) model of MATPSI including additional cleaning and blasting workload not previously modeled.

- A trade study report detailing current industrial technologies that are relevant to the MATPSI cleaning and blasting technologies.
- An alternative design of the MATPSI cleaning and blasting operation, including revised data on equipment, personnel, layout, and scheduling. This design will be tested against the enhanced MATPSI model to evaluate its success in meeting study goals.
- Three monthly status reports describing activities/progress to date.
- A final Contract Summary Report (CSR) summarizing the results of the study and offering MDMSC recommendations for further action.

A list of proposed MDMSC activities on this focus study is included in Table 8.6.4-1. A study criteria checklist is provided in Table 8.6.4-2.

8.6.4.1 Rationale Leading to Change

The current cleaning and blasting capabilities in MATPSI are significant process bottlenecks. Under normal workloads, queues form, at these operations, slowing the flow of products and increasing the volume of expensive WIP inventory in the RCC. Under surge workloads, these queues would become so severe that they would prevent MATPSI from meeting its production requirements.

The problem appears to be one of capacity. While scheduling could alleviate some of the problem under normal workload, a real growth in physical capacity would be required to meet wartime surge demands. To attain this increase in capacity, MDMSC recommends the performance of this focus study.

8.6.4.2 Potential Cost Benefits

The major economic benefit of this study will be in a reduction in the flow time of the products through the shop. This will result in a cost avoidance by a work-in-process inventory reduction. This may be predicted in a manner similar to that

PROJECTED MDMSC ACTIVITIES

TABLE 8.6.4-1

STEP	ACTIVITY
1	Identify and characterize those PCNs which are processed in the MATPSI cleaning facility, but are not currently included in the UDOS model for this RCC. Deliver the enhanced model to SA-ALC.
2	Measure the capacity and response of the MATPSI UDOS model under the new workload conditions to determine the feasibility and sufficiency of the study's goals. Advise SA-ALC of any requirements to modify study goals.
3	Conduct a trade study of the existing cleaning and blasting technologies available on the industrial market and select potential candidates for incorporation into the study. Deliver the study report to SA-ALC.
4	Redesign the current cleaning/blasting facility to meet study goals, incorporating new technology as required. This design will address equipment, layout, personnel, and scheduling.
5	Test the recommended design using the enhanced simulation model. Modify as required. Deliver the new design to SA-ALC.
6	Prepare the monthly status reports and Contract Summary Report. Deliver to SA-ALC as scheduled.

MATPSI FOCUS STUDY CRITERIA CHECKLIST

TABLE 8.6.4-2 (SHEET 1 OF 2)

AREA OF ANALYSIS	ACTIVITY (WHAT & HOW)
Process/Material Flow	Identify the revisions to the process under the new design.
Equipment/Work Place Layout	Prepare list of equipment and a physical layout under the new design.
Facility Requirements	Identify any changes in facility requirements.
Labor Standards	Not directly affected by the study.
Manpower	Determine what manpower and training will be needed under the new design.
Task Assignments	Define the management and organization needed to accomplish any new tasks.
Material Requirements	Define the material and supplies that will be required to support the new design.
Scrap Rates	Scrap rates are not currently tracked. No data available.

LSC-20374A

MATPSI FOCUS STUDY CRITERIA CHECKLIST

TABLE 8.6.4-2 (SHEET 2 OF 2)

AREA OF ANALYSIS	ACTIVITY (WHAT & HOW)
Material Handling & Storage Methods	Establish procedures and handling methods for the new design.
Inspection Techniques	Identify new inspection requirements for the new design.
Equipment/Tools/Fixtures	Identify equipment needed to implement the proposed changes.
Process Delays	Reduce process delays by 50%.
Part Identification	Not directly affected.
Quality	Identify any improvement opportunities.
Personnel Safety	Identify any new requirements.
Environmental Assessments	Environmental impact will be considered.

LSC-20374A

used in paragraph 8.5.4.2. The following factors are deemed appropriate for this study:

- Average flow time reduction is 23 days.
- Value of one set of these parts is $25,000.
- Average annual production is 233 units of each in FY 88.

$$\text{WIP inventory reduction} = \frac{23\text{ days}}{365\text{ days}} \times \$25{,}000 \times 233$$

= $367K with a 23 day average reduction in flow.

8.6.4.3 Risk Assessment of Achieving Goals

While a great deal of advanced cleaning and blasting technology is available on the industrial market, it tends to be capital intensive, especially in areas such as SA-ALC, with environmental constraints. Given the study goal of minimizing new capital investment, MDMSC feels the technological risk associated with this study to be moderate.

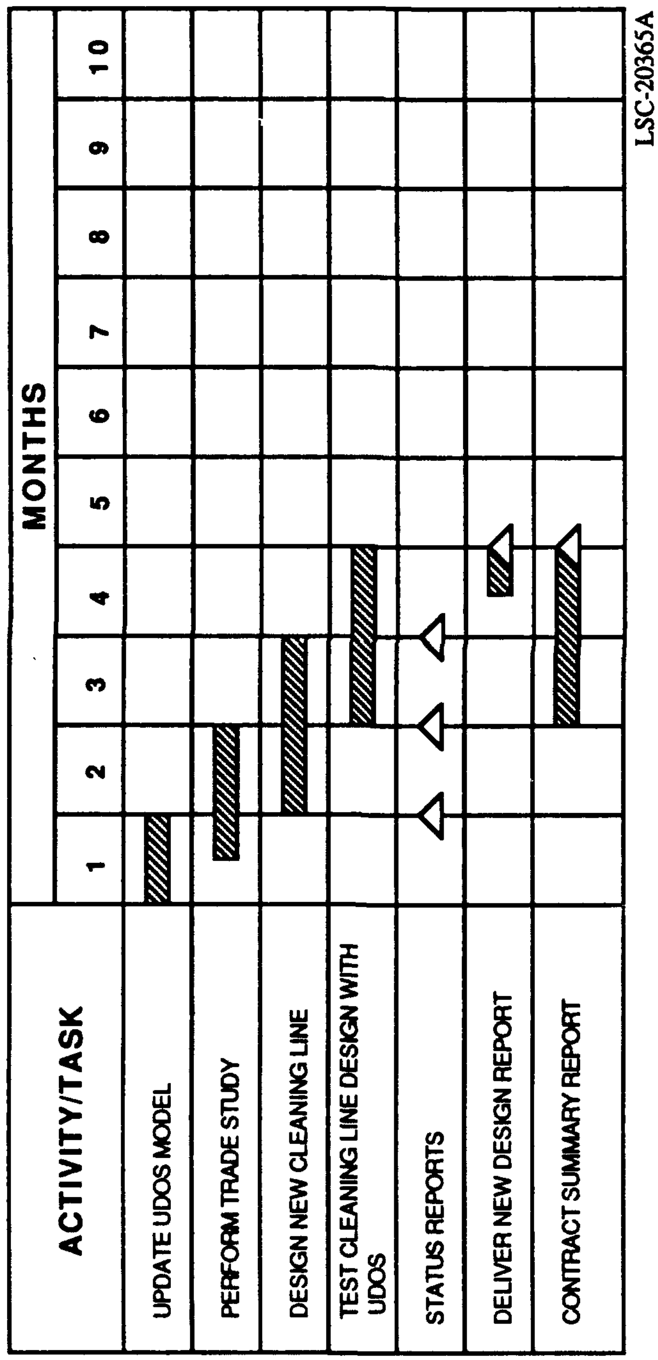
The UDOS 2.0 model for MATPSI is extremely volatile (see paragraph 8.6.2.2) and requires a great deal of subjective interpretation to use. The use of this model, in an enhanced workload configuration, as a performance measurement tool will constitute a modera isk in achieving study goals.

8.6.4.4 Duration and Level of Effort

The proposed program schedule is presented in Figure 8.6.4-1. The total duration of the study will be four months from date of contract turn-on. The level of effort will be:

One MDMSC Industrial Engineer full time	616 manhours
One MDMSC Chemical Engineer 1/2 time	308 manhours
One MDMSC Simulation Specialist 1/2 time	308 manhours

Additional travel will be required during the conduct of the trade study. It is estimated that a total of $250,000 would be required to successfully complete this focus study. This is an engineering Rough Order of Magnitude (ROM)



PROPOSED FOCUS STUDY SCHEDULE

FIGURE 8.6.4-1

estimate for use in engineering trade studies only and does not represent firm pricing.

8.6.5 Other Observations

- Coordinate Measuring Machine (CMM) Environment
  - Current Condition: Evaluation and Inspection (E & I) operators use CMM to evaluate critically dimensioned gas turbine engine parts. Sometimes, especially in hot months, environmental conditions for CMM operations are out of control, and CMM operations have to be temporarily suspended until the proper environmental conditions are restored.
  - MDMSC Recommendation: Implement the necessary procedures to control temperature and humidity year round within the CMM room. Implementation will: (1) restrict personnel access, (2) establish only one room entrance/exit. (3) regulate-monitor air for proper temperature and humidity.
- Automated Prompting Inspection Station (APIS)
  - Current Condition: The APIS pictorially displays each area of the part after it is measured. An inspector then compares the part with its visual representation. The APIS then prompts the inspector to answer a series of questions in order to evaluate the part for areas of repair. Finally a WCD is generated for the repair of the part.
  - MDMSC Recommendation: Modify the APIS with light pen and corresponding monitor so inspectors can mark the location of needed repairs on the display and store the information for future use during an engineering review. Alternatively, implement software and a "mouse" for marking. The information could be recalled and combined with stored information of other parts to reveal where any consistent failures in the parts may be occurring.
- Temporary Parts Storage
  - Current Condition: Incoming and outgoing parts in the inspection and cleaning areas are placed in 24" x 24" x 10" plastic boxes and stacked on each other throughout each area. Workers cannot easily

locate their desired parts but must shuffle the plastic boxes around so they can locate the necessary part.

- MDMSC Recommendation: Purchase or locally manufacture racks for temporary storage of boxes. Also designate areas for certain parts to be in temporary storage so they can easily be located.

• Sonic Cleaner
  - Current Condition: The sonic cleaner is located approximately fifty feet away from the basic cleaning area. The equipment receives a lot of usage and requires the operator to constantly walk back and forth.
  - MDMSC Recommendation: Relocate the sonic cleaner to a point within the basic cleaning area.

• Carts
  - Current Condition: Four wheel carts (18" x 30" x 30") are used throughout the disassembly, cleaning, and inspection areas for moving parts and/or plastic boxes. There is a shortage of these carts.
  - MDMSC Recommendation: Procure additional carts.

• Left Hand and Right Hand F-15 AMAD
  - Current Condition: Labor is wasted on the AMAD units which are condemned by the examination accomplished in operation 40. The disassembly WCDs have an operation number 40, which is approximately half an hour into the process. This operation calls for an examination of the AMAD to determine if it has been exposed to excessive heat and should therefore be condemned.
  - MDMSC Recommendation: Perform the examination called for in operation 40 first and immediately condemn those AMADs which have been overheated .

• Reduce Test Equipment Down Time
  - Current Condition: A hydrostatic test station is used to check the Breech Cap and Chamber Housings for leaks for the cartridge type Jet Engine Starters. During its operating cycle, the test station utilizes water from the local water system and compressed air from a central supply system within the Industrial Technology area. Due to the poor quality of the water and air (both contaminated), orifices in the air

operated pump became clogged frequently. During an eight week period, it was observed that the test station was down four times for repair. The sight glass for the oil supply used to lubricate the air operated pump was empty and the sight glass for the air supply was dirty. Repair time is estimated at two to three days per occurrence.

- MDMSC Recommendation: Modify the test station to add a two-stage filter in the water supply line to filter out particles in the line. Also have a back up pump available for a quick change replacement when the pump malfunctions. Keep the oil supply filled for proper lubrication of the air driven pump. Establish a scheduled Preventative Maintenance program to eliminate the above described process problem for the subject test station.

• Reduce Inspection Costs and Increase Equipment Utilization
  - Current Condition: All disassembled GTE and Jet Engine Starter parts, except hardware items, are sent to MATPSI for inspection. Approximately 175,000 (best estimate) parts were inspected during FY 88. Of these, 20-30% (estimated) received only a visual inspection, nick and burr removal, and corrosion treatment (no dimensional inspection). This visual inspection and rework is accomplished at the Automated Prompting Inspection Stations (APIS) by WG-9 and WG-10 inspectors.
  - MDMSC Recommendation: Establish one or more inspection stations where the visual inspection and rework would be accomplished by lower grade inspectors, utilizing only the visual portion of a modified APIS.

8.7 MATPSS ANALYSIS AND FOCUS STUDY RECOMMENDATIONS

MATPSS assembles, tests, and delivers Aircraft Starters, F-15 and F-16 Jet Fuel Starters (JFS), Accessory Drive Gear Boxes (ADGs), Central Gear Boxes (CGBs) and Airframe Mounted Accessory Drives (AMADs) for various fighter aircraft. The current processes, facilities, equipment and manpower found in this RCC are described in paragraphs 8.7.1.1 through 8.7.1.4. A description of the statistical experimentation is described in paragraph 8.7.2. Significant problems found in the current process are detailed in paragraph 8.7.3, while 8.7.4 describes additional observation of improvement opportunities.

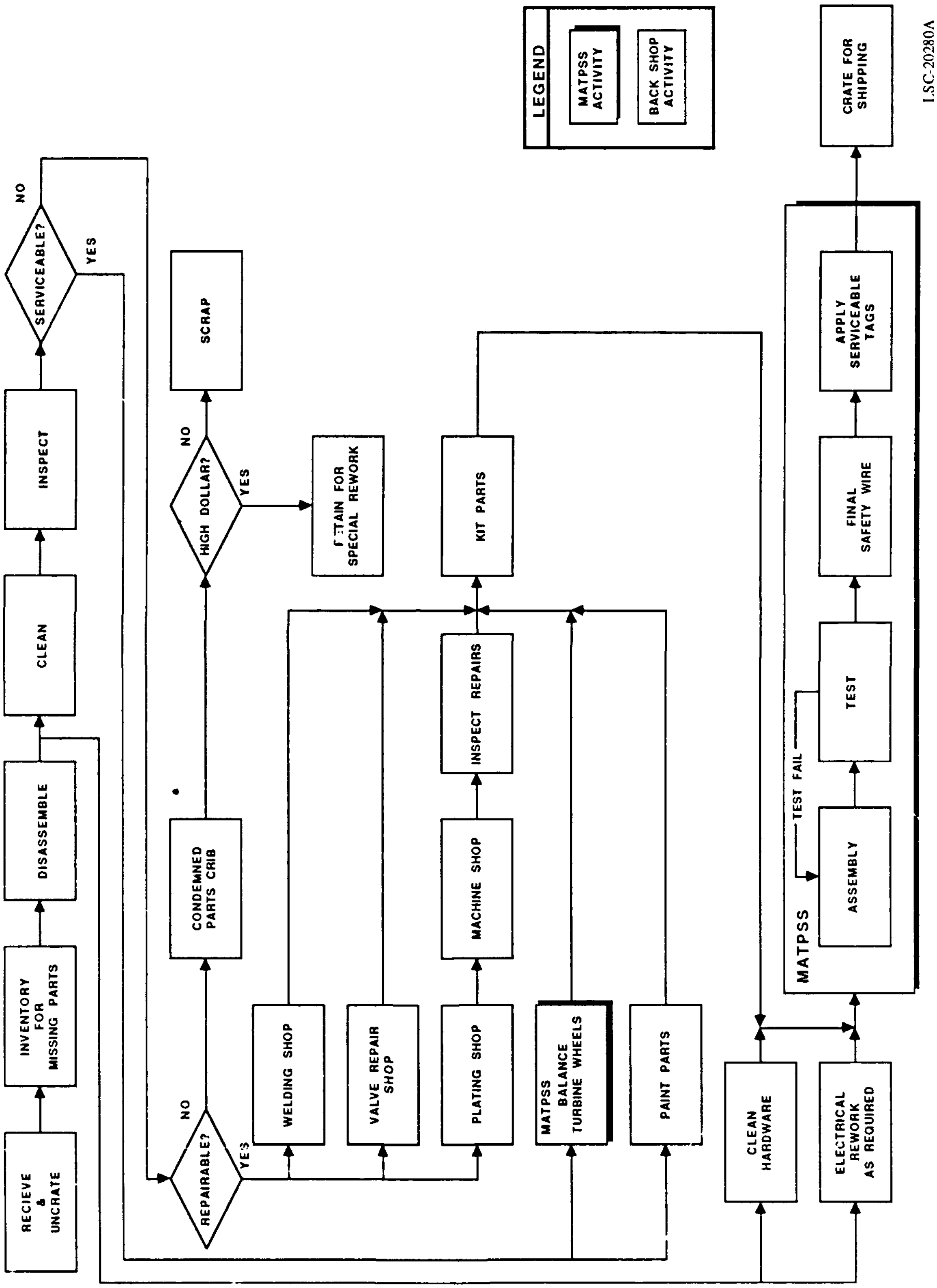
8.7.1 Description of Current Operation

This paragraph summarizes the engineering assessment of the As-Is conditions within MATPSS, including processes, facilities, equipment and personnel. Where appropriate, it includes MDMSC recommendations for changes and identification of strong and weak points in the RCC's operation.

8.7.1.1 Current Processes

The primary workload of MATPSS consists of Management of Items Subject to Repair (MISTR). The 80/20 analysis performed for this RCC identified nine end items for characterization including three aircraft starters, two jet fuel starters, one central and one accessory drive gear box, and the F-15 AMAD gear boxes. These diverse assemblies are assembled in five separate shops within the RCC, each specializing in one type of end item. The typical process flow for these items is shown in Figure 8.7.1.1-1.

These items are received from the MATSS parts pool in kit form. They are assembled by MATPSS mechanics, inspected using visual methods augmented by various gauges and simple measuring tools, and then tested under simulated operating conditions using test cells located in Building 340, except the two AMAD gear boxes which are tested in Building 329. A second inspection is then normally performed, followed by a tag and sell-off of the item. All phases of this process are labor-intensive and demand highly-trained mechanics and inspectors. These processes are described/prescribed by WCDs which may sometimes be obsolete. Certain specific recommendations regarding this



MATPSS PROCESS FLOW
FIGURE 8.7.1.1-1

situation are made in paragraph 8.7.4 but in general it did not appear to be a major problem. The high experience levels of the work force compensate for inadequacies in the WCD process instructions.

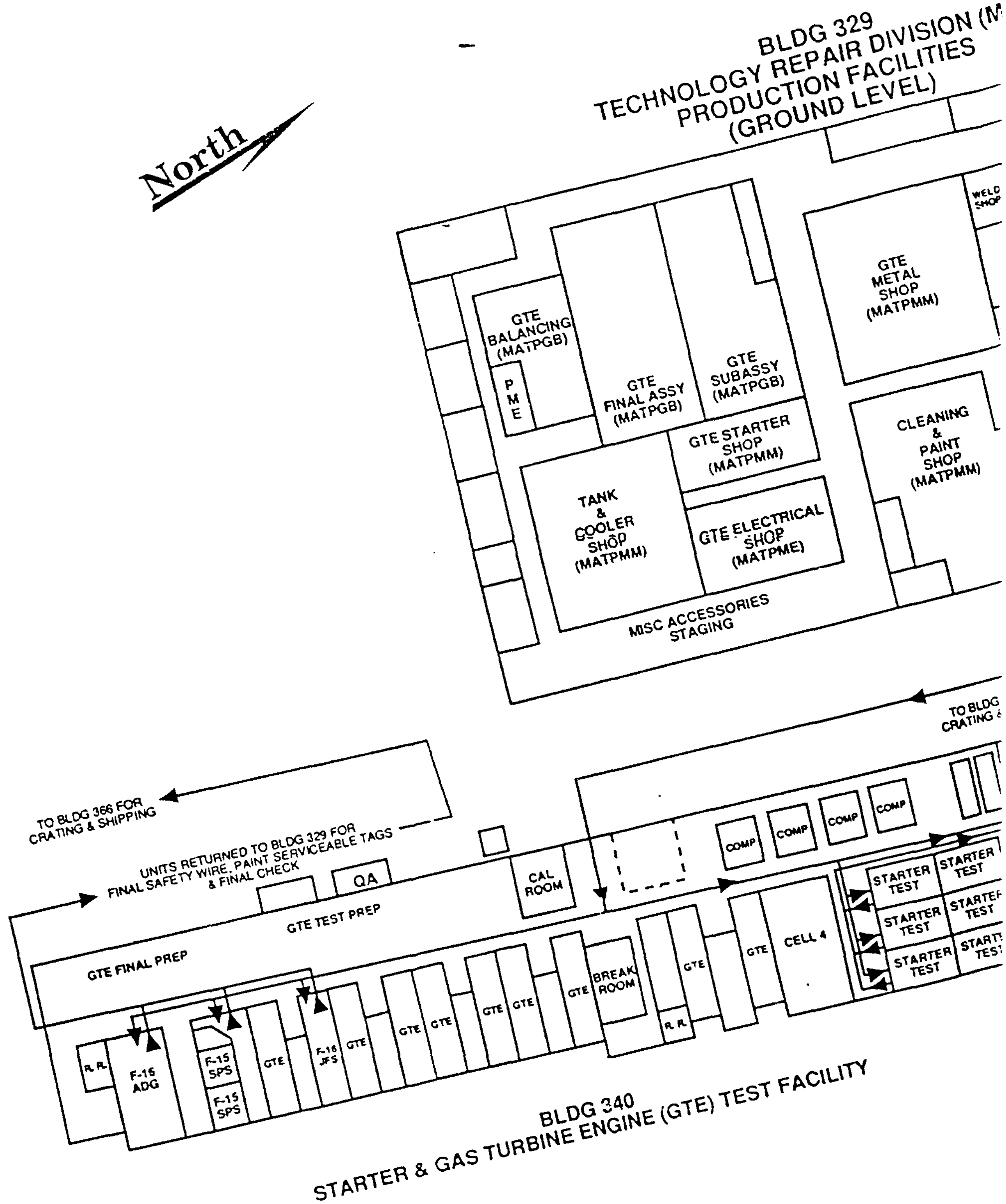
Kits are inducted into MATPSS based on worker availability (availability to begin a part, not to finish it). These kits are assembled into a complete end item, or to some point in the process where a problem occurs. These problems tend to be either the temporary unavailability of a tool or worker (currently assembling a higher priority end item) or the lack of a piece part or subassembly required. When the flow of an item is halted, the workers normally (as directed by their supervision) induct another kit. This tends to produce very high Work-In-Process (WIP) levels--a situation which is described in detail in paragraph 8.7.3.

The most common problem observed in the process flow by MDMSC was the lack of piece parts and subassemblies required to complete the assembly of end items. The enormous volume of WIP, floating stock and stored kits, currently utilized by MATPSS, as well as the wide distribution of official and unofficial bench stocks of small items, masks the true extent of this problem and makes an accurate assessment difficult for MDMSC or SA-ALC engineers. This problem is discussed in detail in paragraph 8.7.3.

8.7.1.2 Facilities

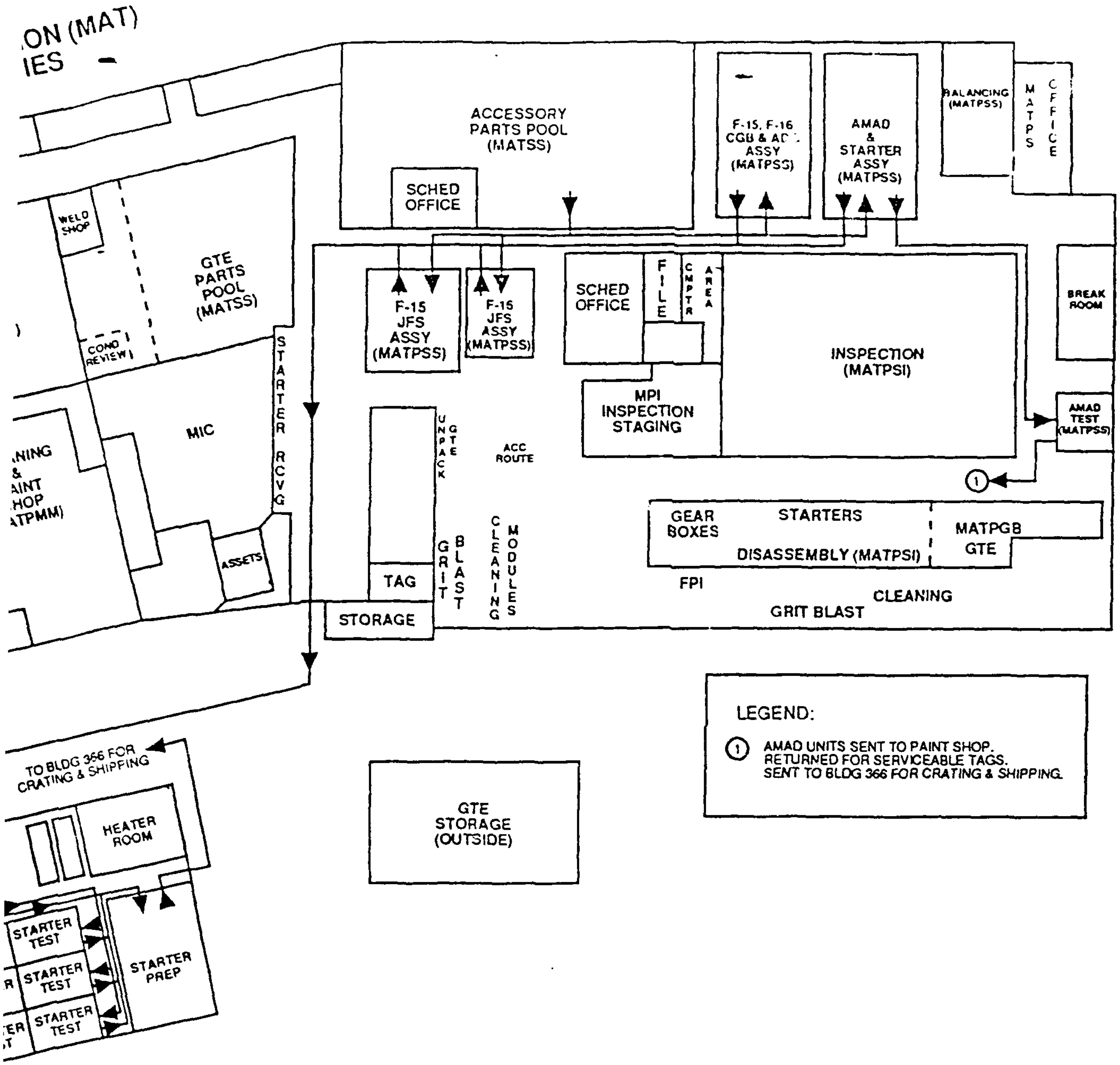
MATPSS occupies space in Buildings 329 and 340. All assembly occurs in Building 329, as well as AMAD testing. All other items are tested in the cells in Building 340. Both buildings are pre-World War II, but are structurally sound and cause no process flow problems. The facilities layout drawings of these buildings, as provided by SA-ALC, are accurate and required no corrections during assessment of this RCC. A copy of the facility drawing, marked up by MDMSC to reflect parts flow, can be found in Figure 8.7.1.2-2.

Assembly is performed in a series of small shops located in an enclosed building module inside Building 329. These shops are air-conditioned, well-lit and have sufficient floor space for the current workload. The bulk of the space is given over to production, as the tools and equipment used in assembly are



North
BLDG 329
TECHNOLOGY REPAIR DIVISION (M
PRODUCTION FACILITIES
(GROUND LEVEL)
GTE BALANCING (MATPGB)
P M E
GTE FINAL ASSY (MATPGB)
GTE SUBASSY (MATPGB)
GTE METAL SHOP (MATPMM)
WELD SHOP
GTE STARTER SHOP (MATPMM)
CLEANING & PAINT SHOP (MATPMM)
TANK & COOLER SHOP (MATPMM)
GTE ELECTRICAL SHOP (MATPME)
MISC ACCESSORIES STAGING
TO BLDG CRATING
TO BLDG 366 FOR CRATING & SHIPPING
UNITS RETURNED TO BLDG 329 FOR FINAL SAFETY WIRE, PAINT SERVICEABLE TAGS & FINAL CHECK
QA
CAL ROOM
COMP
COMP
COMP
COMP
STARTER TEST
STARTER TEST
STARTER TEST
STARTER TEST
STARTER TEST
STARTER TEST
GTE TEST PREP
GTE FINAL PREP
GTE
CELL 4
GTE
BREAK ROOM
GTE
GTE
GTE
GTE
GTE
GTE
GTE
R. R.
R. R.
F-16 ADG
F-15 SPS
F-15 SPS
F-16 JFS
BLDG 340
STARTER & GAS TURBINE ENGINE (GTE) TEST FACILITY

MATPSS PF
F



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SS PRODUCT FLOW (SA-ALC)
FIGURE 8.7.1.2-2

generally small and require little storage space. The large amount of WIP in the assembly process causes every convenient surface to serve as temporary parts storage. The large number of partially assembled items made it extremely difficult for MDMSC engineers to determine what was actually "in-work" rather than waiting on parts, engineering assistance or other service. This is a symptom of the WIP problem discussed in paragraph 8.7.3.

All parts except AMADs must be moved approximately 450 feet to Building 340, using carts, for testing. This is an inconvenience but dos not cause significant problems at normal workloads. The use of highly-skilled mechanics for this type of material handling is not common in commercial industry, however, and is the subject of an MDMSC observation in paragraph 8.7.4.

MDMSC concludes that the current facilities in MATPSS are sufficient to meet current and wartime surge workloads. No capital improvements in facilities were identified which would produce significant improvements in capacity or flow times.

8.7.1.3 Equipment

The bulk of the equipment used in the assembly and inspection process consists of various locally-manufactured holding fixtures and a broad assortment of common and specialized hand tools. Some pneumatically-driven tools are used, but the intricacy of many of the end items tends to limit their usefulness. MDMSC engineering assessment, as well as examination of the UDOS 2.0 equipment utilization rates, indicates that none of these tools or fixtures are significant bottlenecks in the flow of parts through MATPSS. MDMSC concludes that the current quantities of hand tools and assembly fixtures are adequate and that additional equipment would not produce any significant improvement in current MATPSS operations.

Testing of the MATPSS end items is performed using test cells to simulate in-flight operating conditions. These ten cells are located in Building 340, where they are served by four air compressors. The technology in these cells is 1950-1960 technology (analog measuring devices and controls) but adequate for all

projected workloads. Inadequate exhaust capacity in these cells often extends the testing time required for conventional starters to significantly affect item flow time through the RCC. Experimentation with these test cells in the UDOS 2.0 model indicated that they were not a significant bottleneck in production at current or wartime surge levels.

The SA-ALC lift plan calls for the construction of a new building (331) and new, modernized test cells by FY 92. It is MDMSC's conclusion that this expanded and improved test facility will produce only small improvements in MATPSS' ability to produce end items in a timely fashion. MDMSC recommends that no significant capital investment be made in this area before the issues of capacity and scheduling, as described in paragraph 8.7.3, have been addressed.

8.7.1.4 Personnel

MATPSS currently employs 98 production workers with various skill levels and specialities. The experience level of this work force is generally higher than that found in many commercial operations and is a key factor in the successful operation of this RCC. This is discussed in more detail in paragraph 8.7.1.5.

Testing and inspection personnel are all dedicated specialists, at a wage grade of ten. While they may assist other workers in the assembly or material handling tasks, they are the only workers who can certify an item as properly tested or inspected. There are sufficient quantities of these workers to meet normal workload requirements under normal working conditions. Under surge conditions, these workers should work 12-hour shifts to meet production requirements without additional assistance.

MDMSC concludes that manpower in MATPSS is sufficient to meet current and projected requirements. MDMSC recommends that, as mechanics are promoted to the wage grade level ten, they receive training in the inspection and testing operations as soon as practical. This will increase the level of interchangeability among workers and make the RCC more robust to changes in workload or scheduling.

8.7.1.5 Explanation of Current Success

MATPSS is currently meeting all production requirements. This success is due largely to two factors:

- The existence of a large, highly experienced work force with low turnover rates.
- The existence of enormous stocks of end items and subassemblies, in the form of WIP, kits in storage, and official and unofficial bench stocks.

The high experience levels of the work force allow them to function, under adverse conditions, with very little supervision and without detailed scheduling or planning support. The current volume of work-in-process is so large that the overburdened scheduling function is unable to manage the flow of each item. This places responsibility for the management of parts flow squarely on the production workers and their supervision. This situation is unusual in most large commercial repair operations, and can only work with an experienced work force, under very flexible supervision. Most commercial repair centers in the aviation/aerospace business require their scheduling operations to track each major end item through the complete process, especially when end items may belong to one of many different customers. This schedule-driven approach, rather than the current production-driven method, would offer substantial advantages to MATPSS and is discussed in more detail in the focus study recommendation "Reduction of Parts Inventory and Improvement in Flow Time/Throughput," included in paragraph 8.5.4 of this report.

The planning function which supports MATPSS appears to have some difficulty keeping their process specifications current. Several of the WCDs examined during the process characterization/IE assessment proved to be obsolete or inadequate. Specific cases are described as MDMSC observations in paragraph 8.7.4. In each case, however, the workers performing the tasks were aware of the limitations in the WCDs and were changing their own procedures to compensate. Their willingness and confidence in doing this insures acceptable levels of productivity. It also, unfortunately, masks the extent of the problems/costs of using obsolete WCDs and denies the planning operation the feedback needed to identify and correct the problem.

A number of problems were identified in the areas of supply and scheduling which could have severe impact on the ability of MATPSS to meet its production requirements. The consequences of these problems are alleviated, however, by the existence of a huge supply of spares, kits, and bench stocks.

This inventory is primarily under the control of the MATPSS production work force. While kits awaiting assembly are ostensibly under control of the MATSS scheduling operation, the MATPSS work force is normally able to gain access to them with minimal difficulty. These kits are a frequent source of spare subassemblies, alleviating (and masking) the effects of supply difficulties. This allows the RCC to meet its production requirements but increases the amount of unproductive inventory in the RCC. Because of the volume of items involved, and the fluid nature of the situation, it was very difficult to accurately estimate the extent of this problem. MDMSC engineers, using end item acquisition costs, estimated the value of the inventory in the MATSS parts pool at roughly $20 million. The UDOS 2.0 model shows an additional average volume of WIP of $2.4 million. Not even a rough estimate was made of the volume/value of consumable item stocks or end items Awaiting Parts (AWP) or awaiting engineering assistance within the RCC. This volume of inventory is necessary for this RCC to meet production requirements under its current structure, but is phenomenally expensive to maintain. No commercial repair center (in the experience of the MDMSC engineering team) could afford this inventory cost and remain competitive. Further details of this problem are described in paragraphs 8.7.4 and 8.5.4 of this report.

The most significant weakness in the operation of MATPSS, is the difficulty in obtaining support from overburdened scheduling, planning, and engineering functions. The most significant strength is the ability of the work force (including those in scheduling, planning, and engineering) to "work around" these difficulties. Unfortunately, this ability to "work around" severe problems robs management of the feedback they need to solve the problems, and insures their perpetuation. This situation is generally common in American industry. Preventing this situation (i.e. the "Andon light" used in production lines) is a central theme in modern Japanese/Deming management philosophies.

8.7.2 Statistical System Performance Measures

A joint MDMSC/SA-ALC team met 10-14 July 1989 to validate the UDOS 2.0 model for MATPSS. This was accomplished by comparing the simulated throughput and flow time for each PCN modeled to the actual throughput and flow times recorded in FY 88. Other factors, such as process flow, resource utilization, and location of queues were examined as well, in accordance with the Acceptance Test Procedure for UDOS 2.0, previously delivered by MDMSC. The details of this validation process can be found in the validation meeting minutes and in Section 8.0 Validation of the DDB for MATPSS.

After validation was complete, a brainstorming session was conducted with MDMSC and SA-ALC personnel to determine areas of interest for experimentation and to select factors and levels that could be tested to address those areas. The resulting four factors were fit to a Taguchi L_9 Orthogonal array during the brainstorming session, and three test levels were selected for each. A copy of this array, showing the factors and levels selected, is shown in Table 8.7.2-1. The use of this array reduced the number of experimental model runs from 81 to nine.

The experimental runs described in Table 8.7.2-1 were conducted on the UDOS 2.0 model for MATPSS, using FY 88 induction rates for all PCNs modeled. Certain configurations were also tested at war time surge workload levels based on surge figures provided by HQ AFLC. Paragraphs 8.7.2.1 through 8.7.2.4 summarize the conduct and findings of these experiments. The detailed analysis and findings by PCN are provided in Section 10 of the MATPSS DDB.

8.7.2.1 Statistical Analysis of Current Conditions

The current configuration of MATPSS produces an average throughput (number of parts out/number of parts in x 100) of 99% when modeled on UDOS 2.0 (see Table 8.7.2-2 Experiment #1). This throughput figure indicates that the RCC has sufficient production capacity to meet current workloads. No PCN deviates significantly from this average (see Experiments 2-4, Table 8.7.2-2.).

MATPSS L_9 (3^4) TAGUCHI ORTHOGONAL ARRAY

TABLE 8.7.2-1

NORMAL WORKLOAD

EXP #	QTRS RUN	A TEST CAPACITY	B ASSEMBLER TRAINING	C INDUCTION SCHEDULE	D TEST REJECTS
1	4	AS-IS	AS-IS	RANDOM FULL SHOP	10 % (AS-IS)
2	2	AS-IS	+ 7 TRAINED ASSEMBLERS	LEVEL	0 %
3	2	AS-IS	+ 7 UNTRAINED ASSEMBLERS	RANDOM EMPTY SHOP	5 %
4	2	3 SHIFTS 7 DAYS/WEEK	AS-IS	LEVEL	5 %
5	2	3 SHIFTS 7 DAYS/WEEK	+ 7 TRAINED ASSEMBLERS	RANDOM EMPTY SHOP	10 % (AS-IS)
6	2	3 SHIFTS 7 DAYS/WEEK	+ 7 UNTRAINED ASSEMBLERS	RANDOM FULL SHOP	0 %
7	2	3 SHIFT, 7 DAY + 2 STANDS	AS-IS	RANDOM EMPTY SHOP	0 %
8	2	3 SHIFT, 7 DAY + 2 STANDS	+ 7 TRAINED ASSEMBLERS	RANDOM FULL SHOP	5 %
9	2	3 SHIFT, 7 DAY + 2 STANDS	+ 7 UNTRAINED ASSEMBLERS	LEVEL	10 % (AS-IS)

SURGE WORKLOAD

SG1	2	AS-IS	AS-IS	RANDOM FULL SHOP	10 % (AS-IS)
SG2	2	3 SHIFT, 7 DAY + 2 STANDS	+ 7 TRAINED ASSEMBLERS	LEVEL	5 %
SG3	2	3 SHIFT, 7 DAYS + 2 STANDS	+ 7 TRAINED ASSEMBLERS	RANDOM FULL SHOP	5 %

LSC-20575

MATPSS $L_9(3^4)$ TAGUCHI ORTHOGONAL ARRAY THROUGHPUT EXPERIMENTAL RESULTS - FY 88

TABLE 8.7.2-2

EXP #	QTRS RUN	A TEST CAPACITY	B ASSEMBLER TRAINING	C INDUCTION SCHEDULE	D TEST REJECTS	NORMAL WORKLOAD		
						AVG	BEST	WORST
1	4	AS-IS	AS-IS	RANDOM FULL SHOP	10% (AS-IS)	99%	08004A 102%	13096A 94%
2	2	AS-IS	+ 7 TRAINED ASSEMBLERS	LEVEL	0 %	96%	08007A 106%	12712A 97%
3	2	AS-IS	+ 7 UNTRAINED ASSEMBLERS	RANDOM EMPTY SHOP	5 %	97%	13096A 100%	12712A 93%
4	2	3 SHIFTS 7 DAYS/WEEK	AS-IS	LEVEL	5 %	102%	08009A 110%	10718A 99%
5	2	3 SHIFTS 7 DAYS/WEEK	+ 7 TRAINED ASSEMBLERS	RANDOM EMPTY SHOP	10% (AS-IS)	97%	10598A 100%	08007A 93%
6	4	3 SHIFTS 7 DAYS/WEEK	+ 7 UNTRAINED ASSEMBLERS	RANDOM FULL SHOP	0 %	99%	08004A 101%	08007A 97%
7	4	3 SHIFT, 7 DAYS + 2 STANDS	AS-IS	RANDOM EMPTY SHOP	0 %	98%	10598A 100%	08007A 93%
8	2	3 SHIFT, 7 DAYS + 2 STANDS	+ 7 TRAINED ASSEMBLERS	RANDOM FULL SHOP	5 %	100%	08007A 110%	10718A 99%
9	2	3 SHIFT, 7 DAYS + 2 STANDS	+ 7 UNTRAINED ASSEMBLERS	LEVEL	10% (AS-IS)	101%	10718A 107%	08006A 96%

						SURGE WORKLOAD		
SG1	4	3 SHIFT, 7 DAYS + 2 STANDS	+ 3 TRAINED 100%	LEVEL	0 %	92%	08004A 101%	08007A 88%
SG2	4	3 SHIFT, 7 DAYS + 2 STANDS	+ 3 TRAINED 100%	RANDOM EMPTY SHOP	0 %	97%	04542A 100%	08006A 78%
SG3	4	AS-IS	AS-IS	RANDOM FULL SHOP	10% (AS-IS)	94%	12712A 103%	08005A 70%

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Equipment utilization is generally low, with most fixtures used between 10-20%. Only the ZL-93 Test Set (56%) and ZS-23 Holding Fixture (55%) are used more than 1/2 the available time. The test cells described in paragraph 8.7.1.3 are used between 10-40%. This low utilization rate makes it difficult to justify additional capital equipment purchases.

Manpower utilization for the primary skill areas (mechanics and test/inspectors) ranges from 40-55% on all shifts. Only BC/09 mechanics (91% on second shift) exceed this level. This utilization does not include time spent on indirect activities (clean-up, ordering parts, etc.) but does include average time lost to vacation, sick leave, training, and the 20% workload that is unmodeled. While the average utilization rates are low, many parts wait for various skilled workers during their processing. This could be minimized by greater interchangeability among workers, as recommended in paragraph 8.7.1.4.

There are no significant bottlenecks in the current process flow in MATPSS. Although parts show multiple small queues at various points, total average waiting times are less than 48% of flow times, with three PCNs (04542A, 10598A, and 10718A) at less than 4%. These figures do not include delays caused by parts shortages.

The average Work In Process consists of 43.8 end items with a total acquisition cost of $2,223,174. The highest WIP level achieved during the simulation run was 133 items, at a combined acquisition cost of $7,174,527. This does not include uninducted kits in the MATSS parts pool or items delayed in MATPSS awaiting parts or engineering assistance.

8.7.2.2 Experimental Results Under Normal Workload

Factor A - Additional test capacity produced no significant improvements in RCC operations at any level. The spread of test cell operators over three shifts (including weekends) and the addition of two more test cells produced small improvements in flow time, but not enough to justify a recommendation for new equipment or shift work. As previously described, this operation is not a bottleneck in the current process flow through MATPSS, at current production

levels. It does have the smallest capacity in the RCC, however and will be the first bottleneck to occur under surge workloads.

Factor B - Additional Assembly workers - produced no significant improvements in RCC operations at any level. The addition of seven assemblers, either fully trained or as apprentices (modeled at 50% productivity) produced slight improvements for some PCNs, but not enough to justify a recommendation for additional manpower. Manpower in the assembly step is not a bottleneck in the current process flow through MATPSS.

Factor C - Induction Schedule - had a significant effect on throughput when inductions were leveled by limiting the maximum number of end items that could be in-work at any time. Throughput increased an average of 5%, WIP decreased approximately 20% and flow time was largely unchanged. This improvement was caused by the limiting of inductions to a level near the capacity of the lowest capacity operation in the RCC (test cell operation), thus reducing the amount of time parts spent waiting on each other. This change did not increase the actual production capacity of MATPSS, but did eliminate unnecessary delays caused by over induction at the assembly step. By limiting the WIP, a JIT Flow was established, with significant improvement.

Factor D - Rejection Rate - had a significant effect on flow time through the RCC for all PCNs. The rejection rate (and corresponding rework) of all items was modeled at 10% (based on historical records and worker estimates). This rate was reduced experimentally to 5% and 0% and produced a corresponding linear reduction in flow times for each PCN. This gives a strong indication of the benefits that would reward any improvements in the first time quality of the assembly process.

The best combination of these experimental factors is:

Factor	Level
A	3
B	2
C	3
D	2

Figure 8.7.2-2 shows the average throughput of these experiments by experiment number.

8.7.2.3 Experimental Results Under Surge Conditions

Experiments were conducted using war time surge workloads based on figures provided by HQ AFLC. Given the insignificant responses from Factors A and B, and the linear response of Factor D, no orthogonal array was required for surge experimentation.

The current RCC configuration was tested under surge workload conditions (SG1). The total productive capacity of MATPSS was insufficient to meet surge requirements, producing an average throughput of only 92%. The critical bottleneck was the test cell operation, though manpower was tight throughout the RCC. Examination of the resource usage report indicates that surge requirements could be met, without additional test cells, by working all personnel on 12-hour shifts, with weekend work for testers.

The best combination of factors produced by the Taguchi analysis of normal workloads (described in paragraph 8.7.2.2) was tested under surge conditions (SG3). It produced only 94% of the required throughput, but flow times dropped significantly. The problem was in the work-in-process limits, which were set to approximate test capacity at the current, rather than the enhanced level.

The second surge test was repeated (SG2) with WIP limits removed and throughput rose to 97%. MDMSC concludes that improvements in throughput similar to those achieved by Factor C at normal workloads could be achieved under surge by careful adjustment of the WIP limits to match the new test cell capacity.

8.7.2.4 Conclusions and Recommendations

MDMSC concludes that MATPSS has sufficient resources, to meet both normal and wartime surge requirements. As a result of the experimentation conducted, MDMSC offers the following recommendations:

- MDMSC recommends against the purchase of new capital equipment in MATPSS.
- MDMSC recommends against the assignment of additional personnel to MATPSS.
- MDMSC recommends the cross-training of workers between inspection, test cell operation, and assembly as rapidly as current Human Resources policy allows.
- MDMSC recommends that MATPSS management plan for 12-hour shifts and weekend overtime as necessary to meet wartime surge requirements.
- MDMSC recommends that a capacity-driven induction schedule be developed to prevent over-induction and the delays it causes. The development of such a schedule is included in the MDMSC effort proposed in the focus study titled, "Reduction of Parts Inventory and Improvement in Flow Time/Throughput," described in paragraph 8.5.4 of this report.

8.7.3 Description of Process Problems

The single most significant problem with the MATPSS process is the lack of adequate scheduling control and the severe over-induction situation that occurs as a result. This problem causes substantial increases in the amount of work-in-process and the volume of end items stored in the ALC (rather than at forward supply locations where the USAF fleet could use them). The lack of adequate scheduling/parts tracking coupled with the enormous (and enormously expensive) buffer stocks of spares also masks the existence or extent of other problems.

The inventory aspect is the most obvious of the symptoms. Inventories of parts and subassemblies are often called "The Narcotic of Production Managers*." They ease the pain of dysfunctional schedules and keep the line moving. Like narcotics, however, they are extremely expensive, tend to mask other problems and don't really solve anything. If MATPSS (in conjunction with MATPGB and MATPSI) could gain control of its schedule and balance its current assembly line, it could turn what is now expensive inventory into a supply of parts resident at field supply points. This would mean decreased cost for the USAF, who could decrease the volume of spares (through attrition) as well as increased readiness (the combat units in the field would have the spares instead of the ALC). The benefit to the ALC would be shortened, simplified flow that could be more easily managed and improved.

The masking effect of inadequate scheduling, "crutched" by excess inventory is even more critical than the more obvious inventory cost effect. When a problem occurs in production, i.e. inadequate tools, bad materials, or lack of a critical part, the workers (expected to meet production schedules) simply deliver end items that don't need the inadequate tool (they are past that point in production) or cannibalize parts and materials from kits or other items. The result is: work stalls at the trouble point-boosting inventory/WIP, management sees only the production schedule being met and is unaware of the real problem, and workers become frustrated at what they perceive as a lack of management support and demand still more buffer stock to protect themselves. The best specific example of this in MATPSS is the current situation regarding shortages of replacement parts from vendors. Everyone interviewed in the RCC complained (legitimately) of vendor parts problems, and a lack of parts was offered as the primary reason historical flow times for various PCNs were so much longer than the simulated times produced by the model (which does not model parts shortages). Everyone close to the work knows there is a problem, but no one can quantify it or document its cost in productivity because the effects are masked by the schedule/inventory system in use.

* Dr N. Glaskowski, Sr., "KANBAN/JIT Panacea or Plague?" Logistics Spectrum, Summer 1989; Page 15-19

MDMSC does not feel that this problem is the fault of ALC personnel in MATPSS, supply, or scheduling. These people are doing their best in a flawed system. It should be noted that many management experts estimate that 60-90% of all American production lines operate in much the same way (versus less than 5% of the Japanese). The MDMSC recommended solution to this problem is detailed in the focus study, "Reduction of Parts Inventory and Improvement in Flow Time/Throughput," described in paragraph 8.5.4 of this report.

8.7.4 Other Observations

This paragraph describes significant MDMSC observations regarding the production process in MATPSS, which are not detailed elsewhere. These observations and recommendations are included here, rather than as quick fixes, because of the difficulty in quantifying the costs involved in implementing or not implementing the recommendations.

- MATPSS Material Handling
  - Current Condition: The nine MATPSS end items characterized in this Task Order are assembled and painted in Building 329. Seven of them are tested in building 340. During the assembly and test, the components are moved back and forth between the buildings several times. Currently the assembly and test mechanics are transporting the components between the various shops in both buildings.
  - MDMSC Recommendation: Accomplish the transportation of parts or assemblies by the transportation group (MATSS). When a part or assembly has to be expedited from another building or shop, it should be accomplished by labor grade five, not by labor grades nine and ten in order to avoid misuse of skilled mechanics and technicians.
- Central Gear Box Assembly Shop
  - Current Condition: The CGB assembly area has two vises mounted on two work benches. Each mechanic uses a vise several times during the assembly of each CGB. Currently the eighteen mechanics have to haul the parts and tools across the assembly shop to use a vise.

- MDMSC Recommendation: Add new vises to the CGB assembly shop to minimize movement and improve process flow time.

• Central Gear Box Assembly Work Stands
  - Current Condition: Work stands in the gear box assembly area have very limited movement, requiring the mechanics to bend and squat to achieve access and vision inside the gear box.
  - MDMSC Recommendation: Replace or modify the present work stands with double swivel work stands.

• Central Gear Box Safety Wire
  - Current Condition: The last several operations on the CGB final assembly WCDs are calling for the same work as that performed on the test following WCDs. The CGB is assembled, WCD TA144R, and sent to test, WCD TA136R. Then it is returned to final assembly shop for final check, removal of parts, safety wire, and tagging.
  - MDMSC Recommendation: Add operation numbers 116, 121, 126, and 127 to WCD TA144R CGB final assembly. Delete operation numbers 243, 245, 247, 248, 250, 260, 270, 280, and 290 from WCD TA136R CGB test. These nine operations would then be covered by the final assembly WCD TA144R.

• All F-15, F-16 and Starters Assemblies
  - Current Condition: The parts that need to be heated or cooled before pressing are not started until they need to be worked.
  - MDMSC Recommendation: Wherever possible, start the heating and/or cooling far enough in advance of the operation where the parts are to be assembled or disassembled so waiting time can be eliminated. Start a review of WCDs which calls for parts to be heated and/or cooled to facilitate assembly or disassembly.

• Left Hand and Right Hand F-15 AMAD
  - Current Condition: The assembly WCDs presently call for operation number 55 which assembles the lay shaft and then installs it in operation 60. Epoxy is used to repair/replace a seal in this operation and must be allowed to set before the parts can be handled.

- MDMSC Recommendation: Perform the work called for in operation 55 as the first operation of the WCDs so the lay shaft assembly may be set aside and allowed to set before it is needed in the assembly process.

• F-15 and F-16 Jet Fuel Starters
  - Current Condition: The jet fuel starters assembly mechanics have developed a cardboard assembly aid to store the bolts used in buildup of the assemblies. The mechanics select the proper bolts for each location and place them on this template before they begin the assembly operation. This template is made of ordinary corrugated cardboard and has to be replaced regularly.
  - MDMSC Recommendation: Use a more durable material and affix scaled labels on the template to further assist in error-free work. Other uses for this type of template may be found in the other assembly areas.

• Accessory Drive Gear Box Final Assembly Stands
  - Current Condition: The F-16 Accessory Drive Gear Box (ADG) final assembly shop is located along with the CGB in Building 329. Four assembly stands are used by the mechanics to buildup the ADG. Two of the four stands are too high off the floor for the assembly mechanics to perform the assembly. Currently the mechanics are using boxes and other objects to stand on so they can reach on top to perform the assembly.
  - MDMSC Recommendation: Rebuild the existing stands or purchase new stands to improve work force ergonomics and reduce the potential of injury in the ADG assembly shop.

• Central Gear Box Test Reject
  - Current Condition: The test area of the CGB shows a high percentage of rejects during the last twelve months. Using the testing area "log book" MDMSC found that of 1070 CGBs tested, 219 were rejected. Eighty percent of the rejects are due to high vibration of the fan and adapter P/N 367614-1.

- MDMSC Recommendation: Improve inspection and balance all vital parts, like the fan and adapter (P/N 367614-1). Retrain inspectors and balancing mechanics periodically. Recalibrate the testing and inspection equipment more often.

- Starters Test Cell Number 2C
  - Current Condition: Cell number 2C is set up to test the CPS02 mod cartridge starter in Building 340. The exhaust system in the cell is in improper working condition. The exhaust pipes are hanging in disarray over the test stand. The pipes are corroded and do not have the required suction power to remove the gun powder smoke after the cartridge is fired. As a result of this condition, the room and equipment are covered with residue from the firing of cartridges. The test mechanic has to wait over one hour after each firing to be able to enter the test cell to finish the test. (Similar problems exist in other starter test cells.)
  - MDMSC Recommendation: Overhaul or replace the exhaust system in cell 2C to allow the testing operation to be performed efficiently.
- F-15 Jet Fuel Starter Test Cell Number 15A
  - Current Condition: Test cell number 15A is set up to test the F-15 JFS and the CGB in Building 340. The test mechanic has been experiencing problems with the test stand engagement and disengagement gear mechanism for the slave unit used to accomplish the test. Several requests were made by the testers to obtain parts to repair the gear mechanism. The equipment in the test cell is old and obsolete, which makes it hard and time-consuming to obtain replacement parts.
  - MDMSC Recommendation: Fabricate and stock the replacement parts for the equipment before a total breakdown occurs. Periodic overhauls of the equipment need to be performed.
- Inspection
  - Current Condition: When parts are recurringly found to be bad during assembly, Quality Discrepancy Reports (QDR) are written by quality assurance inspectors. The QDRs are received by Supply, which is then aware of suspect parts in supply stores. The store's manager

decides on his own initiative if a discrepant part will or will not be inspected (screened) for the noted discrepancy prior to releasing these parts from the storage area to assembly. When suspect parts so identified are not screened, bad parts continue to be sent to assembly. This affects productivity as bad parts are first discovered on the production floor.

- MDMSC Recommendation: Require all parts in stores to be screened for QDR-noted discrepancies according to a set criteria relating to the number of parts or the number of times a part is found to be discrepant on the production floor.

TECHNOLOGY INSERTION-ENGINEERING SERVICES
PROCESS CHARACTERIZATION
TASK ORDER NO. 1

VOLUME V
SA-ALC

QUICK FIX PLAN
25 SEPTEMBER 1989

CONTRACT NO. F33600-88-D-0567
CDRL SEQUENCE NO. B008 AND B007

MCDONNELL DOUGLAS

McDonnell Douglas Missile Systems Company

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF ACRONYMS AND ABBREVIATIONS

CSR	CONTRACT SUMMARY REPORT
FY	FISCAL YEAR
MDMSC	MCDONNELL DOUGLAS MISSILE SYSTEMS COMPANY
PMR	PROGRAM MANAGEMENT REVIEW
RCC	RESOURCE CONTROL CENTER
SA-ALC	SAN ANTONIO AIR LOGISTICS CENTER
TI-ES	TECHNOLOGY INSERTION-ENGINEERING SERVICES
WCD	WORK CONTROL DOCUMENT

SA-ALC QUICK FIX PLAN

8.0 SAN ANTONIO AIR LOGISTICS CENTER (SA-ALC)

Six quick fix opportunities identified in Task Order No. 1 are presented herein. Four were selected jointly by SA-ALC and the MDMSC TI-ES team, and two were added by MDMSC because of their potential improvement value. The quick fixes are numbered to correspond with their respective paragraphs in the Contract Summary Report (CSR).

The first quick fix opportunity proposes a solution to one aspect of unnecessary back shop flow time by performing dye penetrant inspection for C-5A engine inlet cowls within the shop area of MABPSA. Transit time for the cowl would be virtually eliminated, and control of the end item process and flow time would be controlled by the "parent" shop at an estimated savings of over $2,700.

The second quick fix opportunity recommends that all raw stock be cut to rough size by mechanics assigned to that area rather than having all sheet metal mechanics cutting their own stock. This proposed method will reduce mechanics labor for transporting stock to shears, reduce scrap in work area, and give better control of raw stock inventory. Refer to paragraph 8.3.1 for detail analysis.

The third quick fix opportunity proposes that additional freezer chests be provided in closer proximity to mechanics workbenches to reduce number of trips presently required to get parts out of existing large freezer.

The fourth quick fix opportunity recommends that ID tags made to identify parts be assigned to a mechanic on light duty or a handicapped person. This will permit skilled mechanics to be more productive by not performing a clerical type function.

The fifth quick fix opportunity recommends that a bridge crane be acquired and installed to replace the existing monorail system that has limited capability and capacity. The proposed bridge crane will provide considerably more flexibility and reduce fabrication time.

The sixth quick fix opportunity removes simple inspection and related tasks from skilled assembly mechanics in MATPSS, and places these tasks at an early stage inspection station in MATPSI. Considerable time can be saved by the mechanic who can then concentrate on his main job of assembly (refer to paragraph 8.7.1).

A detailed description of quick fixes for the Resource Control Centers (RCCs) is provided in paragraphs 8.1 through 8.7 of this document.

The quick fix opportunities which follow are presented by RCC. A table of contents section is included for reference, and Table 8.0-1 displays an applicability matrix showing the paragraph number of each quick fix.

QUICK FIX APPLICABILITY MATRIX
TABLE 8.0-1

QUICK FIX TITLE	SCOPE (RCC AFFECTED)						
	MATPGB	MATPSI	MATPSS	MABPSA	MABPSB	MABPSC	MABPSP
REDUCE DYE PENETRANT INSPECTION TIME					8.2.1		
RAW STOCK CUT TO ROUGH SIZE						8.3.1	
FREEZER CHESTS NEAR WORKBENCHES						8.3.2	
IMPROVED PROCESS FOR MAKING ID TAGS						8.3.3	
CRANE FOR ARC WELD & HEAT TREAT SHOP						8.3.4	
REDUCE END ITEM ASSEMBLY TIME			8.7.3				

LSC-20388B

8.1 MABPSA QUICK FIX OPPORTUNITIES

There were no quick fix opportunities identified for MABPSA. All potential improvement opportunities for this RCC are classified as other observations and are described in paragraph 8.1.4 of the CSR.

8.2 MABPSB QUICK FIX OPPORTUNITY

8.2.1 Quick Fix Opportunity to Reduce the C-5A Engine Inlet Cowl Panel Dye Penetrant Inspection Time

8.2.1.1 Description of Current Operations

Presently MABPSB mechanics are moving the C-5A engine inlet cowl from MABPSB sheet metal shop to back shop MABPAN non-destructive inspection and testing unit for dye penetrant inspection.

8.2.1.2 Description of Current Process Problems

MABPSB sheet metal mechanics are spending one manhour to transport the C-5A engine inlet cowl from MABPSB sheet metal shop to back shop MABPAN non-destructive inspection and testing unit. Also an excessive amount of time and interruption to the material transportation flow (aisle traffic) and workers in other stations is caused due to the large size of the C-5A engine cowls.

8.2.1.3 Description of New Process

MDMSC recommends local construction and implementation of roll-out curtains for the C-5A engine cowl stations to enable the inspector to perform the dye penetrant inspection without moving the cowl to the back shop. Have a mechanic from MABPSB attend a dye penetrant certification class or have a certified inspector from MABPAN come to MABPSB to perform the dye penetrant inspection without moving the cowl.

8.2.1.4 Rational Leading to Change

Performing the dye penetrant inspection of the C-5A engine cowl in MABPSB sheet metal assembly shop would eliminate transportation time to back shop and reduce production flow time from 32 hours to four hours.

By implementing the proposed process the throughput of the C-5A engine cowl will be improved and floor space where the cowls are queued will be made available in MABPAN (inspection RCC).

8.2.1.5 Estimated Cost Savings

Current Operations

MABPSB mechanics spend 15 minutes moving C-5A engine inlet cowls from their shop to MABPAN for dye penetrant inspection, and 15 minutes moving them back.

.5 hours per trip x 2 mechanics x $27.59/hour = $27.59/trip
132 trips per year (FY 88) x $27.59 = <u>$3642 yearly cost</u>

New Process

Build a small dye penetrant booth in MABPSB and have an MABPAN inspector walk to MABPSB and perform the inspection on-site. It will only require 15 minutes for the inspector to walk to and from MABPSB.

132 trips per year x .25 hours per trip x $27.59 per hour = <u>$910 yearly cost</u>

Yearly savings: $3642 - $910 = $2732 saved per year.

8.2.1.6 Implementation Cost/Schedule

Implementation Cost

$250 in materials (canvas and framing) for new booth
2 man/days to construct = 8 hours/day x 2 days x $27.59 = $441

Total implementation cost = $691.

The implementation cost will be offset by the first year's savings.

Schedule Impact - None

8.3 MABPSC QUICK FIX OPPORTUNITIES

8.3.1 Quick Fix Opportunity to Provide Raw Stock Cut to Rough Size to Mechanics

8.3.1.1 Description of Current Operations

Currently MABPSC mechanics acquire raw stock from the sheet metal storage area by themselves, or with assistance, depending on the size of stock they need.

8.3.1.2 Description of Current Process Problems

The problem with this method is that it is wasted time for one to two mechanics to go to the storage area, find the stock they need and take it back to the shop and cut it to the size they need. The unused portion of the stock may not always be returned to the storage area, depending on the size left over. If the remaining stock is not returned, it is usually stored in the shop, which causes an accumulation of material.

8.3.1.3 Description of New Process

MDMSC recommends that all material be cut to rough size in the storage area and provided to the mechanics. The rough cut dimensions would be included in the initial operation of the Work Control Document (WCD). This would have to be supported by dedicated mechanics and equipment assigned in the storage area.

8.3.1.4 Rationale Leading to Change

This proposed method:

- would reduce fabrication time.
- would provide better control of raw material.
- should eliminate material shortages due to better control.
- would reduce material usage.
- would achieve better utilization of equipment.
- would have the next job cut to rough size and ready for mechanic to start.

8.3.1.5 Estimated Cost Savings

Based on experimentation performed, it was determined that (1129) hours could be saved if this proposed quick fix, were incorporated.

1129	hours saved/year
x$27.59	/hour
$31,149.11	total savings/year

8.3.1.6 Implementation Cost/Schedule

To implement this proposed quick fix, the following facility and equipment rearrangements would be required:

- prepare raw stock area for a 12' power shear.
- move a 12' power shear from its present location to the raw stock area.
- make all necessary changes and hookups to provide power to shear at new location.

It is estimated that the above changes could be accomplished with six people in two weeks ($13,240).

Schedule impact - none. There is adequate equipment to continue the shearing of raw stock without affecting schedule.

8.3.2 Quick Fix Opportunity to Provide Freezer Chests Near Work Benches

8.3.2.1 Description of Current Operations

Presently there is one large freezer located at the north end of the sheet metal fabrication area and one smaller dry ice box located at the south end of the shop. These freezer boxes are used to maintain the parts in a "W" condition after heat treating.

8.3.2.2 Description of Current Process Problems

With the freezer boxes located in their present location, the mechanics are required to walk considerable distances retrieving parts from the freezers..

8.3.2.3 Description of New Process

MDMSC recommends additional freezers be provided closer to the mechanics' work benches to eliminate the longer distances and multiple trips they are now walking. The mechanics could move a number of pieces from the large freezers to smaller ones in their work areas and save many trips.

8.3.2.4 Rationale Leading to Change

Providing the additional freezers in close proximity to the mechanics' work areas will reduce walking. This will reduce process time.

8.3.2.5 Estimated Cost Savings

Current Operations

It is estimated that the mechanics travel an average of 100 feet each time they leave their work station to get a part out of the freezer (one way).

It is also estimated that there are 12,780 round trips made by the mechanics in a year's time. 25,560 heat-treated parts divided by two parts/trip = 12,780 trips. Each round trip is estimated to take one minute at an average pace.

12,780	round trips/year
1	minute/round trip (200 ft)
12,780	total minutes
÷60	minutes/hour
213	hours

New Process

Provide freezers more centrally located to mechanics' work areas to reduce the distances walked.

Reduce distance walked to an average of ten feet one way or twenty feet round trip.

12,780	round trips/year
12	seconds/round trip (20 ft)
153,360	total seconds
÷3600	seconds/hour
42.6	hours

Yearly savings:

213 hours - 42.6 hours = 170.4 x $27.59/hour = $4701.34 savings/year

8.3.2.6 Implementation Cost/Schedule

Two additional freezers are recommended at an estimated cost of $750.00 each for a total of $1500.00.

Installation and hookup costs would be negligible.

The implementation cost will be offset by the first year's savings.

Schedule impact - none.

8.3.3 Quick Fix Opportunity to Improve Process for Making ID Tags.

8.3.3.1 Description of Current Operations

It is required that two ID tags be attached to each part when it is completed.

8.3.3.2 Description of Current Process Problems

The tags are imprinted by either of two methods:

A) Hand written by mechanic.

B) Printed from an addressograph plate.

If an ID plate is not available from a previously completed part, the mechanic has to make a new plate and print tags. The imprint machine does not always work, forcing the mechanic to imprint ID tags by hand.

8.3.3.3 Description of New Process

MDMSC recommends that this responsibility be removed from the mechanic and assigned to an employee in a lower-skill classification. The tags should be made and provided to the mechanic along with the WCD. The tags could be made for all parts by one person who is either handicapped or on light duty. The tags could be produced by a computerized method which would be more reliable and much faster than current method.

8.3.3.4 Rationale Leading to Change

Present method utilizes higher classification mechanics than necessary. It consumes the mechanic's time performing a clerical task when his skills should be utilized in producing hardware. The proposed method would result in a cost savings of .005 hours per part. A better quality/readable tag would be produced.

8.3.3.5 Estimated Cost Savings

It is estimated that .005 hours per part will be saved between the current and proposed method.

59,105	= 80% of total parts produced for FY 88
÷ 80%	
73,881	= total parts produced
x .005	hours saved/part
369.4	total hours saved
x $27.59	per hour
$10,191.92	total savings based on FY 88 production

8.3.3.6 Implementation Cost/Schedule

Implementation cost is negligible because the method would remain the same, except work would be accomplished by one worker rather than multiple workers.

Schedule impact - none.

8.3.4 Quick Fix Opportunity to Improve Material Handling and Floor Space Utilization for the Arc Weld and Heat Treat Shop.

8.3.4.1 Description of Current Operations

The current operation in the welding and heat-treating shop is limited to a small portion of the floor space due to the limited capacity and capability of the overhead monorail crane. The welders are not able to accomplish all of the work required on the ground support equipment due to lifting and turning limitations. The welders are spending one and a half hours a day hauling the material and equipment to other areas inside or outside the building so they can use a forklift to aid in the handling during construction process. Because the present crane is unable to satisfactorily perform required lifting operations, two manhours a day are lost when material is moved out of the shop for forklift support.

8.3.4.2 Description of Current Process Problems

The current monorail crane system in the welding and heat-treating area has limited capability and capacity. The crane is fixed on one track in a horse shoe shape above a small portion of the work area. The crane is not versatile enough to move the material more than six feet (three feet to each side) under the fixed I beam which supports the hoist. The area workers are pushing, pulling, and swinging the material to get it to the right place so they can perform the job. The present system covers an area of approximately 200 square feet of floor space. Total work area available is 1800 square feet. These problems were observed by MDMSC engineers and concurred with by the most knowledgeable workers in the work area.

8.3.4.3 Description of New Process

The proposed bridge crane will consist of one bridge crane system. The individual system will have two motorized bridge units. Each bridge will have one two-ton motorized chain hoist. The hoists lift with a single speed two horsepower motor and are moved along the bridge by a seventy-five foot per minute two horsepower motorized trolley. The bridge beams will span 30 feet and have an overall length of sixty feet. The bridge beams are single speed units that travel at one rate of one hundred feet per minute.

The proposed system will handle the parts being processed or manufactured in the heat-treat and the weld shops. The capability of interlocking the two hoists together to double the lifting capacity allows the system to assist maintenance personnel to move equipment weighing up to four thousand pounds faster and safer than with a forklift or monorail. The proposed system will cover 1800 square feet of floor space, the current system covers 200 square feet only.

8.3.4.4 Rationale Leading to Change

Bridge crane systems are more flexible because they can operate in straight sequential lines like the monorail, or move perpendicular to the work area. Since bridge crane systems can move in three axes, they are more useful and efficient than monorails. Another benefit is that maintenance personnel can use bridge crane systems to effectively remove and install equipment. A bridge crane will allow the workers to move material in all directions and to complete the job faster, easier, and without interrupting the rest of the workers in the shop. The proposed crane will allow the use of the whole shop floor space available, which is 1800 square feet instead of 200 square feet used currently. In general, private industry shops use bridge cranes instead of monorails for this type of product

The bridge crane equipment is as reliable as any hoisting equipment and has been improved through many years of use. Replacement parts are readily available if the proper supplier is chosen.

8.3.4.5 Estimated Cost Savings

Yearly Savings

MABPSC welders will not have to spend two hours per day average and the forklift operator will not spend an additional 1.5 hours per day for a total of 3.5 hours per day saved on these operations.

3.5 hours/day x 250 days/year x 27.59/hour = $24,141/year

Yearly savings is $24,000.

8.3.4.6 Implementation Cost/Schedule

Implementation Cost

A preliminary verbal estimate of the cost of this system is that it should not exceed $22,000 and take less than three months to install.

The implementation cost should therefore be recovered within the first year of operation.

8.4 MABPSP QUICK FIX OPPORTUNITIES

There were no quick fix opportunities identified for MABPSP. All potential improvement opportunities for this RCC are classified as other observations and are described in paragraph 8.4.4 of the CSR.

8.5 MATPGB QUICK FIX OPPORTUNITIES

There are no quick fix opportunities identified for MATPGB. Discussion with SA-ALC after the August Program Management Review (PMR) resulted in the decision to remove the quick fixes included in the Block I report for MATPGB. The problems were too widespread and could not be quantified. They are now reported as other observations in paragraph 8.5.5 of the CSR along with the other improvement opportunities for this RCC.

8.6 MATPSI QUICK FIX OPPORTUNITIES

There are no quick fix opportunities identified for MATPSI. Discussion with SA-ALC after the August PMR resulted in the decision to remove the quick fixes included in the Block I report for MATPSI. The problems were too widespread and/or could not be quantified. They are now reported as other observations in paragraph 8.6.5 of the CSR along with the other improvement opportunities for this RCC.

8.7 MATPSS QUICK FIX OPPORTUNITIES

8.7.1 Quick Fix Opportunity To Reduce End Item Assembly Time

8.7.1.1 Description of Current Operations

Approximately 25% of all detail parts flow from the disassembly area, go through the cleaning process, bypass inspection, and go directly to the Parts Pool. These parts are primarily hardware items and are maintained as a kit by End Item. The hardware kit is then disbursed along with the End Item assembly parts kit from the Parts Pool to the appropriate assembly area.

8.7.1.2 Description of Current Process Problems

Prior to the start of assembly of an End Item, the first action the assembly mechanic must take is to visually inspect the hardware kit, remove nicks and burrs, and corrosion treat per the WCD.

8.7.1.3 Description of New Process

Establish one or more inspection stations where the visual inspection and rework would be accomplished by lower grade inspectors, as opposed to this work being done by WG-8s and WG-10s in assembly.

This work could be incorporated into the same inspection stations recommended in Other Observations - Inspection Equipment Utilization, Contract Summary Report, paragraph 8.6.5.

8.7.1.4 Rationale Leading to Change

The assembly mechanics (WG-8s and WG-9s) are highly trained and skilled and should not be assigned tasks that could be accomplished by a lower grade level, example WG-5.

By removing visual inspection and rework from the end item assembly mechanic, assembly time will be reduced, flow time will be reduced, and throughput will be increased.

8.7.1.5 Estimated Cost Savings

MATPSS mechanics will take an average of two hours each to perform the visual inspection per the present Work Control Documents for each of the nine end items characterized. In FY 88 approximately 2800 end items were processed. The mechanics are generally on the WG9 pay scale.

2 hours per item x 2800 items x $11/hour = $61,600 yearly cost

Proposed Process:

MATPSI inspectors will take about the same two hours to perform the visual inspections. The inspectors are expected to be WG5 pay grade.

2 hours per item x 2800 items x $9/hour = $50,400 yearly cost

Yearly savings: $61,600 - $50,400 = $11,200 saved per year

8.7.1.6 Implementation Cost/Schedule

Implementation Cost

Two hours to review and switch each Work Control Document from MATPSS to MATPSI for each of nine end items is 18 hours.

2 hours per item x 9 items x $27.59/hour = $496.62

Total implementation cost = $500

The implementation cost will be offset by less than one month's production if WG5s do this instead of WG9s.

Schedule impact - none.